TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

2017 On-Road Mobile Source Annual, Summer Weekday and Winter Weekday Emissions Inventories: Tyler-Longview-Marshall Area

Prepared by the Texas Transportation Institute

A Member of The Texas A&M University System

August 2019

DEVELOPMENT OF 2017 ON-ROAD MOBILE SOURCE ANNUAL, SUMMER WORK WEEKDAY, AND WINTER WORK WEEKDAY EMISSIONS INVENTORIES FOR SPECIFIED AREAS:
TYLER-LONGVIEW-MARSHALL AREA

TECHNICAL REPORT

Final

Prepared for the
Texas Commission on Environmental Quality
Air Quality Planning and Implementation Division

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Texas A&M Transportation Institute
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EXECUTIVE SUMMARY

This work provides the requisite on-road mobile source portion of the 2017 periodic year emissions inventories and county database files (CDBs) for all 254 Texas counties. The State of Texas is required to submit periodic emissions inventories and U.S. Environmental Protection Agency (EPA) Motor Vehicle Emissions Simulator (MOVES) CDBs under the Air Emissions Reporting Requirements (AERR) to support the EPA's comprehensive three-year cycle National Emissions Inventory (NEI). Annual, summer work weekday, and winter work weekday emissions inventory estimates of criteria air pollutants (CAPs), CAP precursors, and hazardous air pollutants (HAPs) were developed. Annual and summer weekday estimates were produced for 254 Texas counties, plus a winter weekday for El Paso County.

This was a three-part analysis to: 1) estimate the seasonal weekday emissions inventories; 2) estimate the annual emissions inventories; and 3) produce the associated inventory mode CDBs. The general methodology was consistent with the process the Texas A&M Transportation Institute (TTI) used to produce the 2014 AERR and HAPs on-road inventories and inventory mode CDBs (i.e., the general methods and procedures were consistent with the 2014 AERR inventories project, but used latest available models and data). Seasonal weekday inventories were estimated using the detailed link-based method, and annual emissions were estimated by converting 24-hour summer weekday estimates to annual estimates using a set of summer weekday emissions and activity annualization factors. The inventory mode CDBs were produced by post-processing inventory data from the first two parts (detailed link-based seasonal weekday inventories and annualization analyses).

To estimate the seasonal weekday county-level inventories in areas where suitable regional travel model data were available, the hourly, MOVES rates-per-activity, detailed travel demand model (TDM) link-based inventory method was used with the latest (readily) available data, models, methods, and procedures.[1] For any counties in these areas not suitably covered by the TDM, the virtual link-based method was used. The virtual link method uses Highway Performance Monitoring System (HPMS) data from the Texas Department of Transportation (TxDOT) as the basis of vehicle miles of travel (VMT) activity. For the remaining counties outside of these areas, TTI used the statewide, virtual link-based method. Hourly and 24-hour inventories were estimated by MOVES source use type (SUT) and fuel type combination (SUT/fuel type or vehicle type), and by roadway class (including the off-network category). A source-classification-code (SCC)-based 24-hour inventory summary was additionally produced. This emissions inventory analysis for all Texas counties was performed by the eight areas shown in Table A, along with the counties for each area and their activity basis (TDM or HPMS).

[1] Although several updates to MOVES2014a have been released, followed by MOVES2014b (additionally with an update), it should be noted that the EPA has indicated that on-road mobile emissions estimates of MOVES model updates after the MOVES2014a November 2016 release are consistent with results from the MOVES2014a November 2016 release (used in this analysis). TTI verified this with model results comparisons. (Most of the new features in MOVES2014a updates and in MOVES2014b were related to non-road mobile emissions.)

Table A. Areas, Counties, and Activity Basis for 2017 AERR Inventories.

Area[1]	Counties	Activity Basis
1. Austin	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson	TDM
2. Beaumont-Port Arthur (BPA)	Jefferson, Hardin, Orange	TDM
3. Dallas-Fort Worth (DFW)	Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise	TDM
4. El Paso[2]	El Paso	TDM
5. Houston-Galveston-Brazoria (HGB)	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	TDM
6. San Antonio	Bexar, Comal, Guadalupe, Kendall, Wilson	TDM
7. Tyler-Longview-Marshall (TLM)	Gregg, Smith Harrison, Rusk, Upshur	TDM HPMS
8. Remainder of Texas	214 counties	HPMS
Totals by Activity Basis	**37** **217**	**TDM** **HPMS**

[1] The 40 "area" counties listed as 1 through 7 in the table were modeled using county level emissions rates, whereas the remaining 214 counties (area 8 in the table) were modeled using the statewide inventory methodology, which produces emissions rate estimates by county groups.
[2] El Paso was the only county for which a winter weekday inventory was produced.

The TDM and HPMS data were post-processed to estimate hourly, directional, link (roadway segment)-level VMT and operational speeds for the emissions calculations. Using estimates of vehicle operating hours (also known as vehicle hours traveled or VHT), vehicle type populations, combination long-haul truck hotelling, and other data, the hourly off-network activity factors were estimated for the off-network emissions calculations. These off-network activity factors are: source-hours-parked (SHP); starts; and source hours extended idling (SHI) and auxiliary power unit (APU) hours, components of hotelling hours for combination long-haul trucks. To develop the emissions rates, post-processing was performed using MOVES input, output, and default data to produce the off-network evaporative emissions rates in terms of mass/SHP (currently not directly provided by MOVES). These emissions rates were compiled with the other rates produced directly by MOVES emissions rate mode runs yielding look-up tables with all rates in terms of mass per vehicle activity unit (i.e., mass/mile, mass/shp, mass/start, mass/shi, mass/APU hour). The final emissions rates inputs to the emissions calculations included only those pollutants required in the emissions inventories, and for affected counties (110 central and eastern counties), were adjusted to incorporate Texas Low Emissions Diesel (TxLED) effects.

The final rates were combined with the appropriate activity estimates in the seasonal weekday emissions calculations. Rates were selected from the rate tables by hour and link-speed for the roadway link-level hourly emissions calculations and by hour for the off-network hourly emissions calculations. A set of MOVES CDBs for use in inventory mode was produced corresponding to these seasonal weekday link-based inventories.

The annual emissions inventories were estimated as a conversion of the detailed, link-based, summer weekday inventories, and resulting output was formatted similarly to the 24-hour summer weekday link-based emissions output (i.e., two tab-delimited summary files were produced, one with standard MOVES category labeling, and one based on SCCs). A set of MOVES CDBs for use in inventory mode was produced corresponding to the annual inventories, consistent with EPA's specifications for MOVES on-road input data submittals for the 2017 NEI.

The SCC-based 24-hour seasonal weekday and annual inventory summaries were converted to an Extensible Markup Language (XML) format suitable for uploading to the Texas Commission on Environmental Quality's (TCEQ) Texas Air Emissions Repository (TexAER) and/or EPA's Emissions Inventory System (EIS).

The inventories were produced using utilities developed by TTI to process on-road vehicle activity (TDM link-based or HPMS roadway-based), off-network vehicle activity, and SUT/fuel type emissions rate data into spatially and temporally detailed emissions estimates for use in air quality modeling.[2] EPA's *Technical Guidance*[3] is the primary technical reference used for guidance on appropriate inputs and use of MOVES.

This analysis included both summer weekday and annual emissions estimates for volatile organic compounds (VOC), carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}); and annual estimates for 70 HAPs including 14 gaseous hydrocarbons, 32 polycyclic aromatic hydrocarbons (16 compounds, estimated in both gaseous and particulate phase components), seven metal compounds, and 17 dioxins and furans. Emissions summaries by the on-road emissions processes available in MOVES were included (refueling emissions processes were excluded). The inventory development activities for all 254 Texas counties were documented separately for the eight areas shown in Table A. This report covers the Tyler-Marshall-Longview (TLM) area counties.

Table B, Table C, and Table D summarize the TLM five-county area 2017 estimates of summer weekday 24-hour CAPs and CO_2 emissions, annual CAPs and CO_2 emissions, and annual HAPs emissions, respectively. Summer weekday VMT and speeds, and annual VMT estimates are additionally included. Note that while Table D includes separate estimated totals of all six priority MSATs (i.e., benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and diesel particulate matter/diesel exhaust organic gases [DPM + DEOG]) and other individual

[2] On-road inventory development utilities for use with MOVES2014a are detailed in *TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUtl,* TTI, August 2016.

[3] *MOVES2014, MOVES2014a, and MOVES2014b Technical Guidance: Using MOVES to Prepare Emissions Inventories for Sate Implementation Plans and Transportation Conformity*, EPA, August 2018.

HAPs or HAPs categories, the DPM +DEOG (estimated as total diesel fleet VOC and PM_{10} exhaust) is not exclusive of the other HAPs listed.

The detailed emissions inventory results in a tab-delimited file format (by pollutant and emissions process, for each vehicle type and roadway category) were provided in electronic form as Appendix A (see description in Appendix A).

Table B. Tyler-Longview-Marshall Area 2017 Summer Weekday Emissions (Tons/Day).

County	VMT	Speed[1]	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Gregg	4,112,017	42.7	1.57	20.45	3.11	2,154.82	0.02	0.11	0.25	0.11
Smith	7,588,779	44.2	3.20	38.94	7.40	4,339.74	0.05	0.21	0.52	0.25
Harrison	3,017,447	50.0	1.13	13.90	4.84	2,307.62	0.02	0.09	0.28	0.17
Rusk	1,562,919	43.3	0.64	8.09	1.41	877.26	0.01	0.04	0.11	0.05
Upshur	1,250,809	44.5	0.58	6.53	1.54	811.81	0.01	0.03	0.11	0.06
Total	**17,531,971**	**44.7**	**7.12**	**87.92**	**18.29**	**10,491.24**	**0.10**	**0.47**	**1.28**	**0.63**

[1] Miles-per-hour, aggregated by county.
[2] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways is included).

Table C. Tyler-Longview-Marshall Area 2017 Annual Emissions (Tons/Year).

County	VMT	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	1,389,391,379	523.42	6,352.30	1,140.14	699,636.06	7.81	35.84	84.60	36.50
Harrison	930,175,255	363.69	4,109.90	1,640.50	688,488.89	5.50	26.21	86.62	52.76
Rusk	528,087,842	213.93	2,530.86	517.45	284,636.58	3.02	14.34	37.46	17.27
Smith	2,564,139,234	1,068.46	12,221.25	2,719.56	1,412,872.29	14.73	69.44	174.49	84.20
Upshur	385,581,447	190.91	1,971.06	521.81	241,856.85	2.25	10.58	35.01	18.58
Total	**5,797,375,158**	**2,360.42**	**27,185.37**	**6,539.46**	**3,327,490.67**	**33.31**	**156.40**	**418.17**	**209.31**

[1] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways is included).

Table D. Tyler-Longview-Marshall Area 2017 Annual Hazardous Air Pollutant Emissions (Tons/Year).

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	MTBE	Eth	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Gregg	13.54	9.74	6.72	2.09	0.67	109.01	0.00	34.27	1.62	0.008	1.29E-07	73.70
Harrison	8.70	11.14	6.10	1.38	0.75	67.48	0.00	19.49	1.67	0.006	7.46E-08	124.34
Rusk	5.52	4.26	2.82	0.85	0.28	44.04	0.00	13.08	0.70	0.003	4.78E-08	35.06
Smith	27.10	24.18	15.05	4.20	1.61	216.21	0.00	66.23	3.76	0.016	2.32E-07	197.44
Upshur	4.87	3.83	2.56	0.77	0.27	38.81	0.00	11.68	0.65	0.002	3.30E-08	37.58
Total	**59.74**	**53.14**	**33.26**	**9.29**	**3.57**	**475.55**	**0.00**	**144.76**	**8.41**	**0.036**	**5.16E-07**	**468.12**

[1] Abbreviations from left: Benzene, Formaldehyde, Acetaldehyde, 1.3-Butadiene, Acrolein, Other Gaseous Hydrocarbon HAPs (Toluene, Xylene, 2,2,4-Trimethylpentane, Hexane, Ethyl Benzene, Styrene, Propionaldehyde), Methyl Tertiary Butyl Ether, Ethanol, Polycyclic Aromatic Hydrocarbons (16 PAHs), Metal Compounds (Arsenic, Chromium, Manganese, Mercury, Nickel), Dioxins, and Furans (17), and diesel particulate matter and diesel exhaust organic gases (represented as total of diesel fleet exhaust VOC and exhaust PM_{10}).

[2] Note that the DPM+DEOG emissions estimates are not exclusive of the other tabulated fleetwide HAPs emissions estimates.

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PURPOSE

This work provides the requisite on-road mobile source portion of the 2017 periodic year emissions inventories and county database files (CDBs) for all 254 Texas counties. The State of Texas is required to submit periodic emissions inventories and U.S. Environmental Protection Agency (EPA) Motor Vehicle Emissions Simulator (MOVES) CDBs under the Air Emissions Reporting Requirements (AERR) to support the EPA's comprehensive three-year cycle National Emissions Inventory (NEI). Annual, summer work weekday, and winter work weekday emissions inventory estimates of criteria air pollutants (CAPs), CAP precursors, and hazardous air pollutants (HAPs) were developed.

BACKGROUND

The Texas Commission on Environmental Quality (TCEQ) works with local planning districts, the Texas Department of Transportation (TxDOT), and the Texas A&M Transportation Institute (TTI) to provide on-road mobile source emissions inventories of air pollutants. TxDOT typically funds transportation conformity determinations required under 40 Code of Federal Regulations (CFR) Part 93. The TCEQ funds mobile source inventory work in support of federal Clean Air Act (CAA) requirements, such as attainment of the National Ambient Air Quality Standards (NAAQS), and the study and control of HAPs, including those from motor vehicles and/or motor vehicle fuels (as mandated under CAA sections 202 and 211).

Under the AERR, states are required to prepare and submit a comprehensive statewide periodic emissions inventory and any applicable modeling inputs every three years. The three-year cycle inventory year for this work was 2017 and was due to the EPA by December 31, 2018. This work required TTI to develop 2017 mobile source model inputs for MOVES and emissions estimates for CAPs, CAP precursors, and HAPs. The on-road mobile CDBs and inventories prepared under this work incorporated recently-collected data for calendar year 2017 and used the newest version of the MOVES model.

DEVELOPMENT OF 2017 ON-ROAD MOBILE SOURCE EMISSIONS INVENTORIES PRE-ANALYSIS PLAN

TTI prepared a pre-analysis plan detailing how TTI was to develop and produce the Texas 2017 on-road mobile source triennial (periodic) emissions inventories and CDBs according to AERR requirements, per the following detailed instructions.

The 2017 on-road mobile source emissions inventories included emissions estimates for CAPs, CAP precursors, and HAPs for the following timeframes: summer work weekday, winter work weekday, and annual. TTI obtained the latest available fleet characteristic data and local 2017 meteorological data.

TTI developed seasonal weekday (winter and summer work weekday) emissions estimates for 2017 by county using the detailed link-based time-of-day methodology for counties with current travel demand models (TDM) available, and for counties without current TDMs using the Highway Performance Monitoring System [HPMS]-based time-of-day methodology. The TDM and HPMS-based counties are shown in Table 1.

Table 1. Areas, Counties, and Activity Basis for AERR and Toxics Inventory.

Area[1]	Counties	Activity Basis
1. Austin	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson	TDM
2. Beaumont-Port Arthur (BPA)	Jefferson, Hardin, and Orange	TDM
3. Dallas-Fort Worth (DFW)	Collin, Denton, Dallas, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise	TDM
4. El Paso[2]	El Paso	TDM
5. Houston-Galveston-Brazoria (HGB)	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	TDM
6. San Antonio	Bexar, Comal, Guadalupe, Kendall, Wilson	
7. Tyler-Longview-Marshall (TLM)	Gregg, Smith Harrison, Rusk, Upshur	TDM HPMS
8. Remainder of Texas	214 Counties	HPMS
Totals by Activity Basis	**37** **217**	**TDM** **HPMS**

[1] The 40 counties listed as (1) through (7) were modeled using county level emissions rates, whereas the remaining 214 counties (8) were modeled using the statewide inventory methodology, which produces emissions rates estimates by county groups.
[2] El Paso is the only county for which a winter weekday inventory was produced.

The EPA requires 2017 emissions inventory data to be reported through the Central Data Exchange (CDX) system. TTI prepared summary files for submittal of the 2017 AERR and HAPs inventories to the CDX consistent with the format requirements of the Consolidated Emissions Reporting Schema (CERS) written in Extensible Markup Language (XML).

TTI produced 2017 AERR CAP and HAP emissions inventories and MOVES CDBs based on pertinent EPA requirements and guidance on development of actual emissions inventories. TTI used emissions inventory development methods agreed upon in consultation with the TCEQ.

Additionally, TTI produced all required emissions inventories consistent with the following bulleted items:

- Used the most recent version of the EPA's on-road emissions model, MOVES2014a, released December 2015, updated November 2016, as the emissions factor model for developing inventories for this task.[4]

[4] Although several updates to MOVES2014a have been released, followed by MOVES2014b (additionally with an update), it should be noted that the EPA has indicated that the on-road mobile emissions estimates of MOVES

- Produced annual and summer work weekday (Monday through Friday) emissions statewide for all 254 Texas counties. Produced winter work weekday (Monday through Friday) emissions for El Paso County only.
- For the CAPs and CAP precursors, developed and produced inventories for three temporal levels: 1) summer work weekday; 2) winter work weekday (El Paso County only); and 3) annual (calendar year totals for all counties).
- Included the following CAPs and CAP precursors in the inventories: volatile organic compounds (VOC), carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}).
- Used summer work weekday and winter work weekday as the day type for the seasonal inventories. Adjusted average daily activity levels for the activity level difference between average annual and average for summer months or winter months and for weekday.
- For the HAPs, developed and produced annual inventories (all 254 counties).
- Included the following HAPs in the inventories produced for this task: the six priority mobile source air toxics (MSATs) (benzene, methyl tertiary-butyl ether, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein); and the additional on-road mobile source air toxic pollutants included in the MOVES2014a database (gaseous hydrocarbons, metals, dioxin/furans, and polycyclic aromatic hydrocarbons). Included all 21 MSATs listed in the EPA's 2001 MSAT rule that are additionally included in the MOVES2014a database.
- Used 2017 climate inputs. Used temperature, humidity, barometric pressure, and other data, as agreed upon and provided by the TCEQ (TCEQ monitoring operations or national climatic data, for subject counties or meteorologically similar county groups).
- Used the most current vehicle miles traveled (VMT) mixes. The VMT mixes were consistent with the EPA MOVES source use types.
- Used the latest available data for the off-network activity development. Developed off-network activity inputs based on current Texas on-road inventory development processes and documented the processes for development in the pre-analysis plan.
- Used the latest available regional registration data as input for locality-specific age distributions.
- Modeled the effects of the oxygenated fuel program for El Paso.
- Used MOVES individual fuel parameter inputs consistent with CFR Title 40 - Protection of the Environment, Part 80 - Regulation of Fuels and Fuel Additives, Section 27 - Controls and Prohibitions on Gasoline Volatility (40 CFR § 80.27).
- Used EPA's 2017 reformulated gasoline (RFG) compliance data and the 2017 fuel property survey data, including Reid Vapor Pressure (RVP), to develop model inputs.

model updates after the MOVES2014a November 2016 release are consistent with results from the MOVES2014a November 2016 release (used in this analysis). TTI verified this with model results comparisons. (Most of the MOVES2014a updates and new features in MOVES2014b were related to non-road mobile emissions.)

The TCEQ provided the 2017 Summer Fuel Field Study Final Report and associated electronic files.

- Modeled the effects of all the federal motor vehicle control programs.
- Modeled RFG for the HGB area and the following four DFW counties: Collin, Dallas, Denton, and Tarrant.
- Modeled the Austin-Round Rock, DFW, HGB, and El Paso inspection and maintenance (I/M) program areas.
- Modeled either federally regulated gasoline and diesel sulfur levels or latest available fuel survey data, as appropriate.
- Quantified VMT by summer and winter work weekday (Monday through Friday): TTI used TDM network link-based VMT for the counties in the seven areas listed previously in Table 1 with current TDMs and used HPMS-based VMT for counties without a TDM.
- Post-processed the diesel vehicle NO_x emissions factors to account for the Texas Low Emission Diesel (TxLED) program, consistent with 30 Texas Administrative Code (TAC) Sections 114.312-114.319. Used year-specific TxLED adjustment factors developed using the benefit information described in the EPA *Memorandum on Texas Low Emission Diesel Fuel Benefits,* and the method as documented in previous Texas on-road inventory development reports.

TTI documented the MOVES modeling approach, inventory inputs, and inventory development procedures in the pre-analysis plan and provided it to the TCEQ.

DEVELOPMENT OF 2017 ON-ROAD MOBILE SOURCE ANNUAL, SUMMER WORK WEEKDAY AND WINTER WORK WEEKDAY EMISSIONS INVENTORIES AND MOVES CDB'S FOR ALL TEXAS COUNTIES

TTI developed and produced the Texas 2017 on-road mobile source triennial (periodic) emissions inventories and CDBs for all 254 counties according to the AERR requirements and to the pre-analysis plan, approved by the TCEQ.

TTI provided inventory summary data in a loadable format compatible with the EPA's Emissions Inventory System (EIS) and the TCEQ's Texas Air Emissions Repository (TexAER). The format was based upon the most recent version of the EPA's NEI format with the CERS written in XML. The loadable inventory files were based upon the source classification codes (SCCs) that are compatible with the 2017 NEI code list. TTI developed and delivered SCC-based inventory files in CERS XML format and tab-delimited format.

TTI developed and delivered a set of MOVES CDBs that included county-specific activity and control program tables sufficient for the CDBs to be used in MOVES inventory mode and produce results consistent with, though not necessarily identical to, the results produced using MOVES rates output and the TTI post-processing inventory development utility. The activity and fleet characterization tables included: VMT; monthly, day-of-week, and hourly VMT distributions; source type populations; and source type age distributions.

TTI provided CDBs in a loadable format compatible with the EPA's EIS. TTI provided the loadable-ready CDBs in conjunction with the emissions inventories.

TTI maintains a record of all electronic files developed or used in conjunction with the completion of this work. TTI submitted all pertinent data relating to this work to the TCEQ in the specified electronic format. The following were included in the electronic file submission:

- A document listing all the files being submitted and detailing file naming conventions;
- MOVES CDBs, MOVES run spec files, and MySQL files used to process data files for MOVES runs;
- All pertinent data relating to task activities;
- Two standard sets of activity and inventory summary files: one based upon MOVES source use types (SUTs) and one based upon the EPA's SCCs;
- TexAER-ready formatted inventory files;
- Inventory files formatted ready for uploading to the EPA's EIS; and
- CDBs formatted and ready for uploading to the EPA's EIS.

Appendix A provides the description of the electronic data submittal.

This report covers the TLM area counties. It is one of eight reports, by geographic area listed in Table 1, documenting development of the 2017 AERR on-road mobile source inventories for all 254 Texas counties. This analysis included both summer weekday and annual emissions estimates for VOC, CO, NO_x, SO_2, NH_3, CO_2, $PM_{2.5}$, and PM_{10}; and annual estimates for 70 HAPs including 14 gaseous hydrocarbons, 32 polycyclic aromatic hydrocarbons (16 compounds, estimated in both gaseous and particulate phase components), seven metal compounds, and 17 dioxins and furans. Emissions summaries by the on-road pollutant emissions processes available in MOVES were included (which excludes refueling processes).

Acknowledgments

Dennis Perkinson, Ph.D., Madhushudan Venugopal, Chaoyi Gu, Stacey Schrank, and Martin Boardman, all of TTI, contributed to the development of the MOVES-based inventories and associated data delivered. TxDOT personnel provided the TDM and HPMS datasets needed. The TCEQ provided meteorological input data. Dr. Perkinson produced the VMT mixes used to divide fleet VMT activity into MOVES SUT by fuel type categories, county VMT control totals, and hourly VMT and other VMT factors. Venugopal processed the TDM- and HPMS-based VMT and speeds, produced the vehicle population estimates, and performed the summer weekday and annual emissions inventory calculations. Schrank produced the off-network activity estimates. Gu and Venugopal produced the inventory XML file summaries and Gu produced the extra set of MOVES CDBs for use with MOVES in inventory mode. Boardman produced MOVES inputs, outputs and performed post-processing to produce the MOVES-based seasonal weekday emissions factors with adjustments for TxLED fuel, as well as MOVES emissions rate annualization factors for the annual emissions analysis. Gary Lobaugh, of TTI, was responsible for editing, design, and production of this technical report. Each member of the assigned TTI staff contributed to the quality assurance of the inventory elements. Dr. Perkinson

was the principle investigator for this project. This work was performed by TTI under contract to the TCEQ. Aaron Slevin was the TCEQ project technical manager.

The discussion is organized in the following sections: Summary of Results, Overview of Methodology, Development of Vehicle Type VMT Mix, Estimation of Summer Weekday VMT, Estimation of Link Speeds, Estimation of Summer Weekday Off-Network Activity, Estimation of Summer Weekday Emissions Rates, Summer Weekday Emissions Calculations, Annual Activity and Emissions, Additional CDBs for MOVES Inventory Mode, Quality Assurance, and References.

SUMMARY OF RESULTS

Table 2, Table 3, and Table 4 summarize the TLM five-county area estimates for 2017 of summer weekday CAPs and CO_2 emissions, annual CAPs and CO_2 emissions, and annual HAPs emissions, respectively. Summer weekday VMT and speeds, and annual VMT estimates are additionally included. Note that while Table 4 includes separate estimated totals of all six priority MSATs (i.e., benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and diesel particulate matter/diesel exhaust organic gases [DPM + DEOG]) and other individual HAPs or HAPs categories, the DPM + DEOG (estimated as total diesel fleet VOC and PM_{10} exhaust) is not exclusive of the other HAPs listed.

The detailed emissions inventory results in a tab-delimited file formats (by pollutant and emissions process, for each SUT/fuel type [or vehicle type] and roadway category) were provided in electronic form as Appendix A (see description in Appendix A).

Table 2. Tyler-Longview-Marshall Area 2017 Summer Weekday Emissions (Tons/Day).

County	VMT	Speed[1]	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Gregg	4,112,017	42.7	1.57	20.45	3.11	2,154.82	0.02	0.11	0.25	0.11
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[1] Miles-per-hour, aggregated by county.
[2] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways is included).

Table 3. Tyler-Longview-Marshall Area 2017 Annual Emissions (Tons/Year).

County	VMT	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	1,389,391,379	523.42	6,352.30	1,140.14	699,636.06	7.81	35.84	84.60	36.50
Harrison	930,175,255	363.69	4,109.90	1,640.50	688,488.89	5.50	26.21	86.62	52.76
Rusk	528,087,842	213.93	2,530.86	517.45	284,636.58	3.02	14.34	37.46	17.27
Smith	2,564,139,234	1,068.46	12,221.25	2,719.56	1,412,872.29	14.73	69.44	174.49	84.20
Upshur	385,581,447	190.91	1,971.06	521.81	241,856.85	2.25	10.58	35.01	18.58
Total	**5,797,375,158**	**2,360.42**	**27,185.37**	**6,539.46**	**3,327,490.67**	**33.31**	**156.40**	**418.17**	**209.31**

[1] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways is included).

Table 4. Tyler-Longview-Marshall Area 2017 Annual Hazardous Air Pollutant Emissions (Tons/Year).

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	MTBE	Eth	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Gregg	13.54	9.74	6.72	2.09	0.67	109.01	0.00	34.27	1.62	0.008	1.29E-07	73.70
Harrison	8.70	11.14	6.10	1.38	0.75	67.48	0.00	19.49	1.67	0.006	7.46E-08	124.34
Rusk	5.52	4.26	2.82	0.85	0.28	44.04	0.00	13.08	0.70	0.003	4.78E-08	35.06
Smith	27.10	24.18	15.05	4.20	1.61	216.21	0.00	66.23	3.76	0.016	2.32E-07	197.44
Upshur	4.87	3.83	2.56	0.77	0.27	38.81	0.00	11.68	0.65	0.002	3.30E-08	37.58
Total	**59.74**	**53.14**	**33.26**	**9.29**	**3.57**	**475.55**	**0.00**	**144.76**	**8.41**	**0.036**	**5.16E-07**	**468.12**

[1] Abbreviations from left: Benzene, Formaldehyde, Acetaldehyde, 1.3-Butadiene, Acrolein, Other Gaseous Hydrocarbon HAPs (Toluene, Xylene, 2,2,4-Trimethylpentane, Hexane, Ethyl Benzene, Styrene, Propionaldehyde), Methyl Tertiary Butyl Ether, Ethanol, Polycyclic Aromatic Hydrocarbons (16 PAHs), Metal Compounds (Arsenic, Chromium, Manganese, Mercury, Nickel), Dioxins, and Furans (17), and diesel particulate matter and diesel exhaust organic gases (represented as total of diesel fleet exhaust VOC and exhaust PM_{10}).

[2] Note that the DPM+DEOG emissions estimates are not exclusive of the other tabulated fleetwide HAPs emissions estimates.

OVERVIEW OF METHODOLOGY

TTI used its detailed TDM link-based, rates-per-activity inventory methodology to produce MOVES-based, on-road vehicle, 2017 seasonal (summer) weekday emissions inventories. To develop the calendar year 2017 annual emissions inventories, TTI used its annualization of summer weekday methodology, for which the summer weekday inventories were a major input.

For seasonal weekday analyses, the TDM link-based, on-road mobile inventory method produces and reports county-level, seasonal weekday, hourly emissions and activity estimates by vehicle type (Table 5), pollutant (Table 6 and Table 7), and roadway-based and off-network-based emissions processes (Table 8). For annual inventory analyses, results are reported similarly, except for the entire calendar year. This section provides an overview of the seasonal weekday TDM link-based inventory methodology, followed by the annual inventory methodology.

For the roadway-based component of the weekday analysis, emissions rates (e.g., grams/mile [g/mi]) produced using MOVES are combined externally with each TDM network link (or roadway segment) VMT estimate (based on link speed and hour) to calculate the roadway-based inventories.

For the off-network component of the weekday inventories, the process requires off-network activity estimates for starts, source hours parked (SHP), source hours extended idling (SHI), and auxiliary power unit (APU) hours. Emissions rates are produced in these activity terms for the off-network emissions calculations. All the activity-based rates required in the TTI inventory process are now directly available from MOVES2014a, except for the SHP-based evaporative rates, which are produced using the TTI inventory utilities.[5]

TTI previously developed the set of external inventory development utilities for use with MOVES that is currently compatible with MOVES2014a. See Appendix B for more information on TTI's MOVES-based inventory utilities.[6]

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[5] MOVES2010b and earlier versions of MOVES provided the off-network start, evaporative, and extended idling rates only in "per vehicle" units, not applicable to the TTI activity-based inventory process; TTI post-processing procedures and utilities were used to produce the MOVES off-network rates in all the needed activity units. The previous version of MOVES (MOVES2014) added several new types of emissions rates (i.e., off-network start and extended idling and APU process rates in terms of mass per unit of activity).

[6] The TTI's MOVES2014a-compatible inventory estimation utilities are detailed in*: TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUTL User's Guide,* TTI, August 2016.

Table 5. MOVES SUT/Fuel Types (Vehicle Types).

SUT ID	SUT Description	SUT Abbreviation[1]
11	Motorcycle	MC
21	Passenger Car	PC
31	Passenger Truck	PT
32	Light Commercial Truck	LCT
41	Intercity Bus	IBus
42	Transit Bus	TBus
43	School Bus	SBus
51	Refuse Truck	RT
52	Single Unit Short-Haul Truck	SUShT
53	Single Unit Long-Haul Truck	SULhT
54	Motor Home	MH
61	Combination Short-Haul Truck	CShT
62	Combination Long-Haul Truck	CLhT

[1] The SUT/fuel type (or vehicle type) labels are the combined SUT abbreviation and fuel type names separated by an underscore (e.g., MC_Gas, RT_Diesel, and SBus_Gas are motorcycles, diesel-powered refuse trucks, and gasoline-powered school buses, respectively).

The methodologies estimate emissions for an estimated regional fleet mix composed of the predominant gasoline-powered and diesel-powered vehicles. Alternative fuel vehicles were treated as *de minimis*.

Table 6. CAPs and CAP Precursors Included in Daily and Annual Inventories.

MOVES Pollutant ID	Pollutant Name	NEI Pollutant Code
2	Carbon Monoxide (CO)	CO
3	Oxides of Nitrogen (NO_x)	NOX
30	Ammonia (NH_3)	NH3
31	Sulfur Dioxide (SO_2)	SO2
87	Volatile Organic Compounds (VOC)	VOC
90	Atmospheric CO_2	CO2
100	Primary Exhaust PM_{10} – Total	PM10-PRI
106	Primary PM_{10} –Brakewear Particulate	PM10-PRI
107	Primary PM_{10} – Tirewear Particulate	PM10-PRI
110	Primary Exhaust $PM_{2.5}$ – Total	PM25-PRI
116	Primary $PM_{2.5}$ – Brakewear Particulate	PM25-PRI
117	Primary $PM_{2.5}$ – Tirewear Particulate	PM25-PRI

Table 7. HAPs Included in Annual Inventories.

Category[1]	MOVES Pollutant ID[2]		Pollutant Name[2]	NEI Pollutant Code[2]
Gaseous HC	20		Benzene	71432
	21		Ethanol	64175
	22		MTBE	1634044
	24		1,3-Butadiene	106990
	25		Formaldehyde	50000
	26		Acetaldehyde	75070
	27		Acrolein	107028
	40		2,2,4-Trimethylpentane	540841
	41		Ethyl Benzene	100414
	42		Hexane	110543
	43		Propionaldehyde	123386
	44		Styrene	100425
	45		Toluene	108883
	46		Xylene	1330207
Polycyclic Aromatic HC (PAH)	**Gas**	**PM**		
	170	70	Acenaphthene	83329
	171	71	Acenaphthylene	208968
	172	72	Anthracene	120127
	173	73	Benz(a)anthracene	56553
	174	74	Benzo(a)pyrene	50328
	175	75	Benzo(b)fluoranthene	205992
	176	76	Benzo(g,h,i)perylene	191242
	177	77	Benzo(k)fluoranthene	207089
	178	78	Chrysene	218019
	168	68	Dibenzo(a,h)anthracene	53703
	169	69	Fluoranthene	206440
	181	81	Fluorene	86737
	182	82	Indeno(1,2,3,c,d)pyrene	193395
	185	23	Naphthalene	91203
	183	83	Phenanthrene	85018
	184	84	Pyrene	129000

Table 7. HAPs Included in Annual Inventories (Continued).

Category[1]	MOVES Pollutant ID[2]	Pollutant Name[2]	NEI Pollutant Code[2]
Metal	60	Mercury Elemental Gaseous	200
	61	Mercury Divalent Gaseous	201
	62	Mercury Particulate	202
	63	Arsenic Compounds	93
	65	Chromium 6+	18540299
	66	Manganese Compounds	7439965
	67	Nickel Compounds	7440020
Dioxin/Furan	130	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	19408743
	131	Octachlorodibenzo-p-dioxin	3268879
	132	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	35822469
	133	Octachlorodibenzofuran	39001020
	134	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	39227286
	135	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	40321764
	136	2,3,7,8-Tetrachlorodibenzofuran	51207319
	137	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897
	138	2,3,4,7,8-Pentachlorodibenzofuran	57117314
	139	1,2,3,7,8-Pentachlorodibenzofuran	57117416
	140	1,2,3,6,7,8-Hexachlorodibenzofuran	57117449
	141	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	57653857
	142	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746016
	143	2,3,4,6,7,8-Hexachlorodibenzofuran	60851345
	144	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394
	145	1,2,3,4,7,8-Hexachlorodibenzofuran	70648269
	146	1,2,3,7,8,9-Hexachlorodibenzofuran	72918219

[1] MOVES models two groups of metal emissions, those used for air quality modeling, and metals due to their known toxicity (i.e., the seven metal species in this table) (See Section 2.3 in *Air Toxic Emissions from On-Road Vehicles in MOVES2014*, EPA, November 2016). The other metals (e.g., iron, aluminum) were not estimated separately as HAPs, but were, by default, included in the aggregate exhaust $PM_{2.5}$ estimates.

[2] These 70 HAPs available in MOVES are the same 70 as identified in Table 1 through 4 of EPA's *Air Toxic Emissions* report. All NEI pollutant codes were taken from the MOVES pollutants table, except for ethanol, which includes a placeholder ID created from the associated CAS number (see Table 1, from the *Air Toxic Emissions* report).

Table 8 shows the MOVES on-road emissions rates with associated processes and activity factors, used in the link-based seasonal weekday analyses.

Table 8. Emissions Rates by MOVES Emissions Process and Activity Factor.

Process (Process ID)	Activity[1]	Emissions Rates[2]
Running Exhaust (1)	VMT	mass/mile (mass/mi)
Crankcase Running Exhaust (15)	VMT	mass/mi
Brake Wear (9)	VMT	mass/mi
Tire Wear (10)	VMT	mass/mi
Start Exhaust (2)	starts	mass/start
Crankcase Start Exhaust (16)	starts	mass/start
Extended Idle Exhaust (90)	SHI	mass/shi
Crankcase Extended Idle Exhaust (17)	SHI	mass/shi
Auxiliary Power Exhaust (91)	APU Hours	mass/APU hour
Evaporative Permeation (11) Evaporative Fuel Vapor Venting (12) Evaporative Fuel Leaks (13)	VMT, SHP	mass/mi, mass/shp

[1] VMT, SHP, vehicle starts, and emissions producing hotelling activity (SHI and diesel APU hours) are the basic activity factors. SHI and APU hours are for combination long-haul trucks only.
[2] All mass per activity rates shown are available in MOVES rate mode table output, except for mass/shp, which is produced using the TTI RatesCalc utility.

Major Inventory Components – Weekday Inventories

The county inventory estimation process requires development of the following major inventory components. All are inputs to the emissions calculation utility, except vehicle populations, which are an intermediate input needed for calculating estimates of SHP and vehicle starts activity.

- District, four-period, time-of-day, vehicle type VMT mix;
- County, hourly, on-road fleet link VMT and average speeds;
- County vehicle type populations;
- County, hourly, vehicle type SHP;
- County, hourly, vehicle type starts;
- County, hourly, combination long-haul truck SHI and APU hours;

- County, hourly, vehicle type MOVES-based on-road rates: mass/mile, mass/SHP, mass/start, mass/SHI, and mass/APU hour; and
- On-road SCCs from MOVES.

The TTI utilities used to develop or process these inventory components are outlined and described in Appendix B, which additionally includes an inventory production process flow diagram.

VMT Mix – Weekday Inventories

The VMT mix designates the vehicle types included in the analysis, and specifies the fraction of on-road fleet VMT attributable to each vehicle type by day type (i.e., average weekday) and by MOVES road type.

The VMT mixes were estimated based on TTI's 24-hour average VMT mix method, expanded to produce the four-period, time-of-day estimates.[7] The procedure sets Texas vehicle registration category aggregations for MOVES SUT categories to be used in the VMT mix estimates, as well as for developing other fleet parameter inputs needed in the emissions estimation process (e.g., vehicle age distributions). The VMT mix procedure produced a set of four-period, time-of-day, weekday, average vehicle type VMT allocations by MOVES road type estimated for each TxDOT district for use with the counties within each district. The data sources used were recent, multi-year TxDOT vehicle classification counts, year-end TxDOT/Texas Department of Motor Vehicles (TxDMV) registration data, and MOVES default data.

On-Road Fleet Link-VMT and Speeds – Weekday Inventories

Time period and day-type-specific fleet VMT and average operational speed inputs were required in the roadway-based calculations (product of "per mile" emissions rates and VMT).

TTI estimated 2017, county, hourly, directional, TDM network link-based, summer weekday VMT and speeds for input to the emissions calculations. For counties without TDMs, TTI estimated HPMS virtual network link-based VMT and speed inputs. County VMT control totals were estimated based on latest available, historical annual average daily traffic (AADT) VMT data (1990 through 2016 HPMS) projected to 2017 and summer weekday adjustment factors. The control totals were distributed by hour and direction to associated TDM network links and added intrazonal links, or to the HPMS virtual links, depending on the county. TxDOT provided the TDM and HPMS datasets. The summer weekday adjustments and hourly distributions used were developed with TxDOT automatic traffic recorder (ATR) data from the local area. Link operational speeds were estimated using TTI's speed model with estimates of link-based volumes, capacities, free-flow speeds, and delay. The county VMT control totals produced were treated as historical (actual) VMT for the analysis.

Vehicle Population and Off-Network Vehicle Activity Estimates – Weekday Inventories

The non-roadway-based inventory estimates (e.g., from vehicle starts, parked vehicle evaporative processes, hotelling activity) were calculated as the product of the amount of associated activity

[7] *MOVES Source Use Type and VMT Mix for Conformity Analysis,* TTI, August 2017.

and the pollutant mass per unit of activity (rate per activity terms as shown in Table 8). To estimate the SHP and vehicle starts activity, vehicle population estimates were needed. Hotelling activity estimates (composed largely of the emissions-producing SHI and diesel APU hours) were based on county-specific actual estimates.[8]

Vehicle Type Populations: TTI based the vehicle population estimates on vehicle registration data, vehicle population factors developed from the VMT mix, and VMT growth estimates. For future years, vehicle type populations are estimated as a function of base (e.g., latest available, mid-year) registrations, grown to a future value (growth as a function of base and future county-level VMT), and all roads-weekday VMT mix-based vehicle type population factors for the analysis year. The latest available mid-year TxDMV registrations data were for 2014, thus VMT growth estimates were used to scale vehicle population estimates from 2014 to the 2017 analysis year.

SHP**:** The SHP was estimated as a function of total hours (hours a vehicle exists) minus its hours of operation on roads (source hours operating [SHO], which is the same as vehicle hours travelled [VHT]). For a historical year, the vehicle type SHP estimates are based on VMT mix, link VMT and speeds, and the vehicle population estimates. The VMT mix is applied to the link VMT to produce vehicle-type-specific VMT estimates. Link VMT is divided by the associated speed to produce SHO estimates, which are aggregated by vehicle type and subtracted from the associated source hours resulting in the SHP estimates. For a future year the vehicle type SHP is estimated in the same manner as for historical years, except using the future year link VMT and speeds, VMT mix, and vehicle population estimates. Although 2017 is historical, the SHP procedure was treated as a forecast, since vehicle populations were forecast. This was performed for each county by hour.

Starts: Engine starts were based on the MOVES national default starts per vehicle, and the local, county, vehicle population estimates. MOVES default weekday starts per vehicle were used. The starts were calculated as the product of starts/vehicle from MOVES, and the local, county, vehicle type population estimates. This was performed for each county by hour.

SHI and APU Hours: The SHI and APU hours, two activity components comprising the diesel combination long-haul truck hotelling hours, were estimated for each county using TTI's current procedure and new, base, hotelling activity estimates from the TCEQ's 2017 truck idling study. TTI used the 24-hour winter weekday 2017 baseline, county level hotelling estimates from the truck idling study in combination with winter weekday to summer weekday adjustment factors to produce summer weekday 2017, county, hourly hotelling activity estimates. Hotelling hourly factors (estimated by inverting hourly VHT factors) were then applied to allocate the 24-hour hotelling hours estimates for each county to each hour of the day. Estimated SHI and APU hours fractions of hotelling hours based on an updated hotelling activity distribution from the truck idling study were used to separate SHI and APU hours activity from total hotelling hours, for each county and hour.

[8] Base estimates of hotelling hours used in this analysis are 2017 winter weekday estimates, developed by TTI during the truck idling study that produced county 24-hour hotelling estimate totals for all Texas counties, sponsored by the TCEQ beginning in 2017.

MOVES Emissions Factors – Weekday Inventories

TTI produced the emissions rates look-up table inputs to TTI's EmsCalc inventory calculation utility in three basic steps. The first step was to set up and execute the MOVES emissions rate mode runs. The next step was to perform the initial post-processing, which calculates rates in the form needed that are not directly available from MOVES. Performing the final post-processing to make needed adjustments and screen out non-applicable pollutants finished the process.

Local input parameters were developed and used to produce rates reflective of the local scenario conditions (e.g., weather and fleet characteristics, fuel properties, I/M program where required). MOVES county scale, rates mode modeling scenarios produced rates for the MOVES weekday day type by pollutant, process, speed (for roadway-based processes), hour, road type, and average vehicle type. Two rates post-processing steps were performed to produce the final rates in the form needed. The first step produced the mass-per-SHP off-network evaporative rates not available from MOVES. The final rates post-processing step extracted the rates needed in the inventory calculations (i.e., screened out any unneeded pollutants/processes remaining from the previous step), and made adjustments, where required (e.g., for estimated TxLED effects on diesel vehicle NO_x rates, for affected counties).

County-level, MOVES weekday hourly emissions factors were developed. Actual, local, activity estimates for each county were then externally combined with the associated emissions rates in the EmsCalc utility inventory calculations.

Inventory Calculations – Weekday Inventories

Inventories were calculated for each county using the EmsCalc utility. The major inputs in summary were: TxDOT district-level, weekday, time-of-day VMT mix by MOVES road type; county, hourly, on-road fleet, link VMT and speed estimates; county, hourly, off-network activity estimates by vehicle type of SHP, starts, SHI, and APU hours; and county-level look-up tables of hourly MOVES weekday rates by road type, speed bin, vehicle type, pollutant and process.

For the VMT-based calculations, county-to-TxDOT district, TDM or HPMS road type/area type-to-MOVES road type, and hour-of-day to time-of-day period designations were used to match the appropriate VMT mixes with the link VMT. The VMT mixes by MOVES road type were multiplied by the link fleet VMT to distribute each link's VMT to the different vehicle types. Emissions rates for each link's average speed were interpolated (see procedure in Appendix B) from the appropriate set of look-up table rates and corresponding index speeds (i.e., the average bin speeds of 2.5, 5.0, 10.0, 15.0, … 75.0 mph), bounding the link's average speed. For link speeds below or above the minimum and maximum average bin speeds of 2.5 and 75 mph, the rates for those bounding speeds were used. The estimated vehicle type and MOVES road type link-speed-specific rates for each process were then multiplied by the associated VMT to produce the link-based estimates. This process was performed for each hour, by county.

For the off-network calculations, which are county level, the vehicle type, county-level rates were multiplied by the associated county total activity estimate (starts, SHP, SHI, APU hours), as determined by the pollutant process. This process was performed for each hour, by county.

The on-road mobile inventory utilities produce two types of tab-delimited summary output files (optional hourly link-emissions files for photochemical modeling applications were excluded). The standard on-road tab-delimited output file includes hourly and 24-hour activity and emissions results summarized by vehicle type and road type. The SCC tab-delimited output feature produces 24-hour activity and emissions data in a form (aggregated and re-coded with SCCs) consistent with the EPA's 2017 NEI, as needed for uploading specified inventory data to the TCEQ's TexAER and EPA's EIS.

TTI further prepared the summer weekday inventory data for uploading to the TCEQ's TexAER and EPA's EIS by converting the SCC-coded inventory output to the required uploadable format (EPA's EIS NEI CERS XML format), using TTI's MOVESsccXMLformat utility. Appendix A contains more information on the output definitions and specifications, including the inventory data formatted for compatibility with TexAER and EIS.

TTI developed and maintains a series of computer utilities used to calculate and summarize detailed, on-road mobile source, emissions inventories in various formats, such as those used in this analysis. Appendix B describes these applications.

Inventory Calculations – Annual (Year) Inventories

The annual activity and emissions were calculated by converting (or annualizing) the average summer weekday emissions using two sets of annualization factors: activity annualization factors, and emissions rate annualization factors.

The activity annualization factors (for VMT, starts, SHP, and hotelling hours) were developed using annual activity (developed using similar calculation procedures to MOVES) and the average summer weekday activity. The activity annualization factors were calculated by dividing the calculated annual activity by the summer weekday activity from the emissions inventory development process.

The emissions rate annualization factors were developed using the emissions and activity output from specialized annual and summer weekday MOVES inventory mode runs. Annual and summer weekday emissions rates were calculated by dividing the MOVES emissions output by the appropriate MOVES activity output, producing both annual and summer weekday emissions rates. The emissions rate annualization factors were calculated by dividing the annual emissions rate by the summer weekday emissions rate.

The annual activity was calculated by multiplying the summer weekday activity by the appropriate activity annualization factor. The annual emissions were calculated by multiplying the summer weekday emissions by the appropriate activity annualization factor and by the appropriate emissions rate annualization factor. In some cases, emissions rate annualization factors did not exist due to no emissions in the summer weekday MOVES inventory mode run. An example is where hydrocarbon start emissions are equal to zero, for certain heavy-duty diesel-powered source types (i.e., combination trucks and transit buses), and where the minimum daily temperature is 75 degrees Fahrenheit or higher. In these cases, the annual emissions were calculated by multiplying the annual emissions rate by the annual activity.

As with the summer weekday inventories, two types of tab-delimited summary output files were additionally produced for the annual inventory estimates. The standard on-road tab-delimited output file includes annual activity and emissions results summarized by vehicle type and road type. The SCC tab-delimited output produced includes annual activity and emissions data aggregated and coded consistent with the EPA's 2017 NEI, as needed for uploading inventory data to the TCEQ's TexAER and EPA's EIS.

TTI further prepared the annual inventory data to the upload-ready format needed for the TCEQ's TexAER and EPA's EIS by converting the SCC-coded inventory output to the required EPA EIS NEI CERS XML format, using TTI's MOVESsccXMLformat utility. Appendix A contains more information on the output definitions and specifications, including the inventory data formatted for compatibility with TexAER and EIS.

Additional Inventory Mode MOVES CDBs

TTI developed two sets of MOVES CDBs (one for the seasonal weekday period and one for annual period) that included county-specific activity and control program tables sufficient for use in MOVES inventory mode to produce results consistent with, though not necessarily identical to, the results produced using MOVES rates output and the TTI post-processing inventory development utility.

TTI initially produced these additional summer weekday and annual inventory mode CDBs with a standard set of 26 MOVES data tables sufficient for local county MOVES inventory runs. The local data tables were produced by post-processing county link-based inventory data into the required MOVES formats and tables. TTI subsequently updated the additional annual inventory mode CDBs, as needed for submittal to the EPA for the NEI, by expanding the set of CDB tables and re-naming the CDBs to EPA's specifications. The MOVES annual CDBs for the NEI include 36 tables consistent with the EPA requirements.[9]

DEVELOPMENT OF VEHICLE TYPE VMT MIX

VMT mix is a major input to the MOVES link-based emissions estimation process. It is an estimate of the fraction of on-road fleet VMT attributable to each SUT by fuel type, and is used to subdivide the total VMT estimates on each link into VMT by vehicle type. These hourly VMT estimates by vehicle type are combined with the appropriate vehicle type-specific emissions factors in the link-based emissions calculations.

Since the VMT mix can vary by time-of-day (and thus have an effect on the emissions totals), the TTI VMT mix procedure includes the option to develop VMT mix by time period. This feature is used in detailed, hourly link-based emissions analyses. Time period VMT mix (by MOVES roadway type and vehicle type) consists of four time periods: morning rush hour (AM peak), mid-day, evening rush hour (PM peak), and overnight.

TxDOT district-level, time period, and Weekday (average Monday through Friday) VMT mix (for gasoline-powered and diesel-powered vehicles) is estimated by the four MOVES

[9] The on-road inputs submittal guidance is in *Instructions for Submitting ONROAD Inputs for the 2017 NEI,* EPA, July 31, 2018.

road-type categories using the methodology characterizing VMT by vehicle type for a region (or district) as follows.[10]

1. MOVES – Data files of MOVES default values extracted from MOVES databases or *pro forma* runs.
2. TxDOT Classification Counts – Data files of standard TxDOT classification data assembled and used for determining the in-use road fleet mix.
3. TxDMV Registration Data – Data files of standard TxDMV vehicle registration summary data assembled and used for determining the in-use road fleet mix.
4. TxDOT ATR Data – Data files of TxDOT ATR data assembled and used to allocate VMT by season and day of week.
5. Single Unit Local vs. Total SUT_HDVyy – Procedure based on registration data to generate factors to separate Single Unit versus Combined Unit trucks by region. (SUT_HDVyy has multiple outputs based on vehicle category and fuel.)
6. Combination Local vs. Total SUT_HDXyy – Procedure based on registration data to generate short-haul and long-haul combination truck proportions by region.
7. Day of Week (DOW) Factors by Urban Area/TxDOT District – Seasonal day-of-week factors from TxDOT ATR data used to allocate VMT by season and day-of-week by urban area/TxDOT district.
8. Single Unit Short-Haul vs. Long-Haul SUT_SSHZ – Procedure to separate single unit short-haul versus single unit long-haul using factors generated from SUT_HDVyy and classification count data. Short-haul and long-haul are functionally defined as local and pass through.
9. Combination Short-Haul vs. Long-Haul SUT_CSHZ – Procedure to separate combined short-haul versus combined long-haul using factors generated from SUT_HDXyy and classification count data. Short-haul and long-haul are functionally defined as local and pass through, respectively.
10. PV and LDT Fuel MF_Fuelyy – Procedure to generate passenger vehicle and light truck fuel allocation by year based on MOVES national default values and local registration data.
11. Single Unit and Combination Truck Fuel SUT_HDVyy – Procedure to generate single unit and combined truck fuel allocation factors from registration data. (SUT_HDVyy has multiple outputs based on vehicle category and fuel.)
12. SUT_yyddtt – Procedure to generate SUT proportions by year, day type, and time period, based on the previous steps.
13. MOVES SUTs – Output file of MOVES SUTs by region, analysis year, day type, and time period.

[10] *MOVES Source Use Type and VMT Mix for Conformity Analysis,* TxDOT Air Quality/Conformity IAC-A - TTI Task 409480-0843: Maintain, Update and Enhance Traffic Activity Estimation and Forecasting Methods, Texas Department of Transportation, Austin, TX. October 2017.

TxDOT district-level Weekday VMT mixes by MOVES road-type category were produced based on recent multi-year vehicle classification counts and appropriate end-of-year TxDMV vehicle registrations data. Using the same datasets and a similar procedure, aggregate (i.e., all road-type categories), TxDOT district-level weekday vehicle type VMT mixes (used in the vehicle population estimation) were additionally produced. To ensure general applicability and consistency across all study areas, all VMT mixes were developed in five-year increments and applied to analysis years based on Table 9. The 2015 VMT mix estimates for the Atlanta District (for Harrison and Upshur Counties) and the Tyler District (for Gregg, Rusk and Smith Counties) were used. Appendix C provides a summary of the four period time-of-day, weekday VMT mixes used. Appendix D provides a summary of the all roads aggregate, 24-hour weekday VMT mix used.

Table 9. VMT Mix Year/Analysis Year Correlations.

VMT Mix Year	Analysis Years
2010	2008 through 2012
2015	2013 through 2017
2020	2018 through 2022

ESTIMATION OF SUMMER WEEKDAY VMT

The detailed, hourly, link-based emissions inventory development process requires VMT estimates by hour and direction for each link in the TDM networks and the HPMS virtual networks (i.e., HPMS functional class/area type combination virtual links). Additionally required were VMT adjustments for consistency with HPMS VMT and adjustments to estimate 2017 average summer weekday levels. The TRANSVMT utility, the latest available datasets from the Longview 2020 TDM (Gregg County) and the Tyler 2020 TDM (Smith County). The VirtualLinkVMT utility and HPMS-based virtual networks (based on latest available 2016 HPMS AADT VMT data) were used for the virtual link-based counties (Harrison, Rusk, and Upshur). The hourly and 24-hour VMT and VHT summaries by county and road type were provided electronically to the TCEQ (see Appendix A for electronic data descriptions and Appendix B for utility descriptions).

Data Sources

The three major data sources for producing the link VMT and speed estimates for the five TLM area counties include the TDM datasets, HPMS datasets, and ATR data, all provided by TxDOT.

The latest available link data, trips data, and zonal radii datasets from the Longview 2020 TDM (24-hour assignment dated January 11, 2011) and Tyler 2020 TDM (24-hour assignment dated May 19, 2010) were used to estimate the directional link VMT and speeds by hour. Since intrazonal VMT are not accounted for in the TDM, the intrazonal VMT was estimated using the TDM's trip matrix and zonal radii datasets. The TDM VMT represents average non-summer weekday traffic (ANSWT).

TxDOT compiles Texas HPMS data in its annual Roadway Inventory Functional Classification Record (RIFCREC) reports. The latest available RIFCREC report for this analysis was 2016. The HPMS VMT estimates are based on traffic count data collected according to a statistical sampling procedure specified by the Federal Highway Administration (FHWA) designed to estimate VMT. The HPMS VMT, centerline miles and lane miles estimates by seven road types and four area types (shown later in the estimation of speeds section) form the basis of TTI's virtual link VMT and speeds estimation method for counties without TDMs. County total HPMS AADT VMT is additionally used to ensure TDM VMT is consistent with HPMS VMT. (EPA and FHWA have endorsed HPMS as the appropriate source of VMT and require that VMT used to construct on-road mobile source emissions estimates be consistent with that reported through HPMS.)

ATR vehicle counts are collected by TxDOT at selected locations throughout Texas on a continuous basis. These vehicle counts are available by season, month, and weekday, as well as on an annual average daily basis (i.e., AADT). These counts are well suited and used for making seasonal, day-of-week, and time-of-day comparisons (e.g., seasonal adjustment and hourly allocation factors), even though there may be relatively few ATR data collection locations in any given area. Multiple years (2007 through 2016) of data from the ATR stations were aggregated at the TxDOT district level to produce factors for use with each district's respective counties. Seasonal factors were produced for converting AADT VMT to the seasonal day-type scenario-specific VMT. Seasonal and day-type-specific hourly travel factors were additionally produced for allocating VMT to each hour of the day. TxDOT Atlanta District factors were used for Harrison and Upshur, and Tyler District factors were for Gregg, Rusk, and Smith counties.

VMT Adjustments

The VMT adjustment procedures are different depending on whether the analysis year is a future year or a historic year. The 2017 inventory analysis year was treated as a historical year for VMT adjustments. The historical year procedure for estimating VMT for link-based emissions inventory analyses requires development of analysis year, scenario-specific (i.e., 2017 summer weekday), 24-hour, county VMT control totals. The county control total VMT is divided by model total VMT (either TDM ANSWT VMT or HPMS AADT VMT, depending on TDM availability) to produce the VMT adjustment factor for each county.[11] On a county-by-county basis, applying the county VMT factor to its associated link-level model VMT accomplishes both ensuring consistency with HPMS VMT and conversion (or scaling) of link-level model VMT (e.g., 2016 AADT VMT or 2020 ANSWT VMT) to link-level 2017 summer weekday VMT.

[11] Although treated as a historical year for the purpose of HPMS consistency and summer weekday adjustments, the 2017 HPMS AADT VMT used in the summer weekday control totals (numerator of the VMT adjustment factor) was actually a forecast, since the 2017 historical HPMS AADT VMT was not yet available. TTI forecast the 2017 AADT VMT using its standard procedure, taking the mid-point of two forecasts: 2017 VMT from the linear regression of county HPMS AADT VMT (1990 through 2016) and 2017 VMT based on 2017 county human population statistics and VMT per capita estimates. These county 2017 HPMS AADT VMT estimates were converted to summer weekday using the ATR-based TxDOT Atlanta and Tyler Districts AADT to summer weekday factors, respectively, of 1.12039 and 1.08307.

TDM-Link-Based Adjustments

For the TDM counties, the VMT adjustment factors were calculated by dividing the county's respective control total by the county's respective total TDM VMT (TDM assignment VMT plus intrazonal VMT estimate for the county). For each link in the TDM, the volume was multiplied by the corresponding VMT adjustment factor (based on the county where the link was located). The adjusted link volumes were then multiplied by the associated link lengths to produce the 2017, link-level, HPMS consistent, summer weekday VMT estimates. Table 10 shows the 2017 summer weekday VMT control totals, the total TDM VMT, and the VMT adjustment factors for each TDM-based county.

Table 10. 2017 Summer Weekday VMT Control Totals and VMT Adjustment Factors for Longview and Tyler TDM Counties.

County	VMT Control Total	TDM VMT[1]	VMT Adjustment Factor
Gregg	4,112,017	4,980,252	0.825664477
Smith	7,588,779	8,405,640	0.902819895

[1] 2020 TDM, including intrazonal VMT, rounded to nearest mile.

HPMS Virtual Link-Based Adjustments

For the HPMS-based counties, the VMT adjustment factors were calculated by dividing the county's respective control total by the county's respective total historical HPMS VMT (latest available 2016 HPMS AADT VMT for the county). For each county, each virtual link VMT estimate in the base HPMS AADT data set was multiplied by the county's 2017 summer weekday VMT adjustment factor, resulting in the link-level, HPMS consistent, 2017 summer weekday VMT estimates. Table 11 shows the 2017 summer weekday VMT control totals, the base HPMS VMT total, and the VMT adjustment factors for each HPMS-based county.

Table 11. 2017 Summer Weekday VMT Control Totals and VMT Adjustment Factors for HPMS Virtual Link-Based Counties.

County	VMT Control Total	HPMS VMT[1]	VMT Adjustment Factor
Harrison	3,017,447	2,648,674	1.139229079
Rusk	1,562,919	1,423,060	1.098280381
Upshur	1,250,809	1,098,100	1.139066227

[1] Latest available, historical 2016 HPMS AADT VMT, rounded to nearest mile.

Hourly Travel Factors

Hourly travel factors were used to distribute the fleet link VMT to each hour of the day. The Tyler TxDOT District factors were used with Gregg, Rusk, and Smith counties and for the Atlanta TxDOT District factors were used with Harrison and Upshur counties. For TDM-based counties each factor was multiplied by the link volume (in addition to the VMT adjustment factors). Each adjusted link volume was then multiplied by its link length to estimate the hourly link level, 2017 summer weekday VMT estimates. The factors were additionally multiplied by the intrazonal VMT to produce the final hourly-adjusted VMT. For virtual-link based counties each factor was multiplied by the link-level 2017 summer weekday VMT to produce the virtual link VMT estimates for each hour. Table 12 shows the weekday hourly travel factors.

Table 12. TxDOT District Summer Weekday Travel Factors.

Hour[1]	Atlanta	Tyler
1	0.014877	0.006778
2	0.012623	0.004790
3	0.011641	0.004020
4	0.011697	0.005147
5	0.013870	0.009674
6	0.022582	0.024013
7	0.034665	0.047195
8	0.046885	0.072149
9	0.047525	0.056524
10	0.050088	0.050936
11	0.053797	0.051698
12	0.058358	0.052811
13	0.061286	0.056285
14	0.062205	0.057657
15	0.063546	0.060875
16	0.066590	0.068066
17	0.068756	0.076684
18	0.071355	0.088110
19	0.057925	0.063086
20	0.047709	0.044838
21	0.040490	0.036532
22	0.034164	0.029147
23	0.026870	0.020053
24	0.020496	0.012932

[1] Hour 1 is 12:00 a.m. to 1:00 a.m., etc.

Time-of-Day Directional Split Factors

Previously developed directional split factors were used to produce the VMT and speeds by direction for both the TDM-based counties and the HPMS-based counties. For the TDM-based counties, these factors were multiplied by the link volume to estimate the volume of travel in each direction, one record containing the estimated volume in the peak (or dominant) direction, and the second record containing the estimated volume in the opposite direction. These directional volume estimates were used not only to estimate the VMT in each direction, but additionally to estimate the directional speeds (discussed in the next section). These time-of-day directional split factors were taken from the Technical Note, *Northeast Texas Region On-Road Mobile Source Modeling Emissions Inventories: 1995, 1999, 2002, 2005, 2007, and 2012*, TTI, August 22, 2003. The directional split factors were initially based on functional class and not facility type. A correlation table was developed to relate the functional-class-based directional splits to the facility types listed in the model. Appendix E contains the directional splits.

The directional split factors were developed for application by time-of-day period (Table 13), at the functional classification (Table 14), and area type level (Table 15).

Table 13. Tyler-Longview-Marshall Time-of-Day Travel Periods.

Period	Hours
AM Peak	6 a.m. - 9 a.m.
Mid-Day	9 a.m. – 4 p.m.
PM Peak	4 p.m. – 7 p.m.
Overnight	7 p.m. - 6 a.m.

Table 14. Longview and Tyler TDM Facility Types.

Facility Type Code	Facility Type Description	Longview TDM	Tyler TDM
0	Centroid Connector	✓	✓
1	Radial IH Freeways - Mainlanes Only	✓	✓
10	Circumferential Expressways (Loops)		✓
11	Principal Arterial – Divided	✓	✓
12	Principal Arterial - Continuous Left Turn Lane	✓	✓
13	Principal Arterial – Undivided	✓	✓
14	Minor Arterial – Divided	✓	✓
15	Minor Arterial - Continuous Left Turn Lane	✓	✓
16	Minor Arterial – Undivided	✓	✓
17	Collector – Divided	✓	
18	Collector - Continuous Left Turn Lane	✓	
19	Collector – Undivided	✓	✓
20	Frontage Road	✓	
21	Ramp (Between Frontage Road and Mainlanes)	✓	✓

Table 15. Longview and Tyler TDM Area Types.

Area Type Code	Area Type Description
1	Central Business District (CBD)
2	Urban
3	Suburban
4	Rural

For the virtual link-based counties, A 60/40 directional split ratio was applied based on aggregate observed values. The hourly, directional VMT estimates for each link were then divided by the link's centerline miles to produce the link volume estimates required for input to the speed model (discussed in the next section).

Hourly and 24-hour county VMT summaries (by road type and vehicle type) for each inventory scenario were produced and were included with the detailed inventory data provided (see inventory data file descriptions in Appendix A).

ESTIMATION OF LINK SPEEDS

To estimate link operational (congested) speeds, a speed model involving both the link estimated free-flow speed and estimated directional delay (as a function of volume and capacity) was used. This model was used to estimate the hourly, directional, congested speed for each link, except for the TDM centroid connectors and added intrazonal links. The congested speed was calculated using the following formula:

$$Congested\ Speed = \frac{60}{\dfrac{60}{Freeflow\ Speed} + Delay}$$

Speed model input parameters (i.e., free-flow speed and delay) were estimated differently depending on whether the county was TDM-based or virtual link-based.

TDM-Based Estimation of Link Speed

Free-flow speed factors were used to convert TDM speeds (which are by definition level of service [LOS] C) to LOS A speeds (free flow). For each facility type and area type combination, the free-flow speed factors were calculated by dividing the free-flow speed by the corresponding speed from the speed/capacity look-up table used for the TDM. The free-flow speeds were determined using the Highway Capacity Manual (HCM), using suitable assumptions to relate the HCM data to the facility types used in the TDMs. Appendix E shows the free-flow speed factors used by area-type/functional-class combination.

The second component of the speed model used to calculate the congested speed is the estimated directional delay. The directional delay (in minutes per mile) due to congestion was calculated using the following volume/delay equation:

$$Delay = Min\left[A\,e^{B(\frac{V}{C})}, M\right]$$

Where:

Delay = congestion delay (in minutes/mile);
A & B = volume/delay equation coefficients;
M = maximum minutes of delay per mile; and
V/C = time-of-day directional volume-to-capacity (v/c) ratio.

The delay model parameters (A, B, and M) are shown in Table 16, followed by Table 17, which lists the functional classes used in the TDMs and their capacity category (except for centroid connector and intrazonal, which do not use capacity data).

Table 16. Volume/Delay Equation Parameters.[1]

Facility Category	A	B	M
High-Capacity Facilities	0.015	3.5	5
Low-Capacity Facilities	0.050	3.0	10

[1] MOVES2014a-Based Virtual-Link Emissions Estimation Method, Texas A&M Transportation Institute, August 2016.

Table 17. Facility Type Categories for Applying Delay Parameters.

Category	TDM Facility Type Code	TDM Facility Type Description
High-Capacity	1	Radial IH Freeways - Mainlanes Only
Low-Capacity	10	Circumferential Expressways (Loops)
	11	Principal Arterial - Divided
	12	Principal Arterial - Continuous Left Turn Lane
	13	Principal Arterial - Undivided
	14	Minor Arterial - Divided
	15	Minor Arterial - Continuous Left Turn Lane
	16	Minor Arterial - Undivided
	17	Collector - Divided
	18	Collector - Continuous Left Turn Lane
	19	Collector - Undivided
	20	Frontage Road
	21	Ramp (Between Frontage Road and Mainlanes)

The time-of-day directional v/c ratios were estimated using the directional volume (from the VMT estimation) and the time-of-day directional capacity. However, the 24-hour user equilibrium assignments were performed using non-directional 24-hour capacities. To estimate the time-of-day directional capacity, the directional split for capacity was assumed at 50/50 and capacity factors were multiplied by the non-directional capacity for each link. Appendix E summarizes the capacity factors for the TLM region TDMs by area type/facility type combination. Capacity factors were calculated using the following formula:

$$\textit{Capacity Factor} = \frac{\textit{(Hourly Capacity per Lane) (Length of the Time Period)}}{\textit{24 - Hour Capacity per Lane}}$$

Capacity data are not used, however, for the centroid connector links and the added intrazonal links (added specifically for air emissions analyses). The centroid connector traffic assignment input speeds were used as the centroid connector operational speeds estimates. Operational speeds for the intrazonal trips category were estimated by zone as the average of the zone's centroid connector speeds.

Virtual Link-Based Estimation of Link Speed

The capacities and free-flow speeds used in the virtual link procedure are based on the HCM. For HPMS functional classifications 1 and 2 (Interstate and Freeway), both capacities and free-flow speeds are consistent with HCM guidance (HCM Chapters 13 and 30). The capacity (2,400 passenger cars per hour per lane [pcphpl]) and free-flow speed (70 mph) for four-lane Freeways is used for all Interstates and rural Freeways. Similarly, a free-flow speed of 65 mph and capacity of 2,300 pcphpl is used for small urban and urban Freeways (HCM Exhibits 13-3 and 30-2).

The only adjustment applied to these two highest-level roadways is for the impact of heavy trucks on capacity (which is measured in passenger car equivalents). Table 18 shows the capacities for Interstates and Freeways based on the VMT mix for these roads in the three area types (procedure discussed next), and HCM-designated passenger car equivalents (1.5 per HCM Exhibit 23-8).

Table 18. Adjusted Interstate and Freeway Flow Rate (pcphpl) by Area Type.

<table>
<tr><th>Area Type</th><th>Ideal Flow</th><th>HDV</th><th>Factor</th><th>Adjusted Flow</th></tr>
<tr><td>Rural</td><td rowspan="3">2,400</td><td>0.2832</td><td>0.8760</td><td>2,102</td></tr>
<tr><td>Small Urban</td><td>0.1140</td><td>0.9461</td><td>2,271</td></tr>
<tr><td>Urban</td><td>0.0616</td><td>0.9701</td><td>2,328</td></tr>
<tr><td>Rural</td><td rowspan="3">2,300</td><td colspan="3">NA</td></tr>
<tr><td>Small Urban</td><td>0.1140</td><td>0.9461</td><td>2,176</td></tr>
<tr><td>Urban</td><td>0.0616</td><td>0.9701</td><td>2,231</td></tr>
</table>

HPMS functional classifications 3, 4, 5, 6, and 7 (Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local) are interrupted flow facilities (i.e., they have traffic control devices). The capacities of these interrupted flow facilities are estimated as a function of adjusted flow and available green time (per HPMS Appendix N, Equation 20):

$$Cap = Sat \times (gr/c).$$

Where:

Cap	=	capacity of lane group, vehicles per hour (vph);
Sat	=	saturation flow rate of lane group, vehicles per hour of effective green time (vphg); and
gr/c	=	effective green ratio for the lane group.

The saturation flow rate (Sat) is the flow in vph that could be accommodated by the lane group assuming that the green phase is always available to the lane group (i.e., green ratio = 1.0). Calculation of the adjusted saturation flow rate begins with the ideal saturation flow rate (HCM Exhibit 10-12) of 1,900 pcphpl, which is adjusted to reflect deviation from ideal conditions. The saturation flow rate is adjusted using the following logic (from HCM equation 16-4, with parameter estimates consistent with HCM Exhibit 16-7 and Chapter 10):

$$S = fw \times fhv \times fg \times fp \times fbb \times fa \times flu \times frt \times flt \times flpb \times frpb$$

Where:

S	=	saturation flow rate adjustment factor;
fw	=	lane width factor (NA, 12-foot lane for all area types assumed);
fhv	=	heavy vehicle adjustment factor (based on area type VMT mix);
fg	=	approach grade factor (NA, level terrain assumed);
fp	=	parking lane adjustment (NA, unusual for rural or small urban areas, inappropriate for urban areas given HPMS aggregation);
fbb	=	bus blocking factor (NA, negligible per area type VMT mix);
fa	=	area type adjustment (NA, since the default of 0.9 is for urban area CBDs and urban is more broadly defined in HPMS);
flu	=	lane utilization adjustment (NA, data unavailable in HPMS);
frt	=	right turn adjustment factor (exclusive lanes for urban areas, 90 percent shared lane for right turns for rural areas, midpoint for small urban areas);
flt	=	left turn adjustment factor (exclusive lanes for urban areas, 90 percent shared left turn lanes for rural areas, midpoint for small urban areas);
flpb	=	left turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity on average); and
frpb	=	right turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity).

Table 19 shows the saturation flow rate adjustment factors used for the three different area types. Unitary factors (i.e., factors whose value is 1 for all area types, or which are otherwise not applicable) for parameters fw, fg, fp, fbb fa, flu, flpb, and frpb are not shown.

Table 19. Saturation Flow Rate Adjustment Factors by Area Type.

Area Type	fhv	Frt	flt	Factor
Rural	0.8918	0.9850	0.9950	0.8740
Small Urban	0.9380	0.9175	0.9725	0.8369
Urban	0.9661	0.8500	0.9500	0.7801

Table 20 shows the adjusted saturation flow rate (expressed in pcphpl) for all interrupted flow facilities (i.e., signalized streets, not Interstate or Freeway) for the three area types.

Table 20. Adjusted Saturation Flow Rate (pcphpl) by Area Type.

Area Type	Ideal Flow	Adjustment Factor	Adjusted Saturation Flow
Rural	1,900	0.8740	1,661
Small Urban		0.8369	1,590
Urban		0.7801	1,482

Table 21 shows the effective green ratios used for different functional classes and area types. Since the virtual link procedure is highly aggregated, individual green ratio calculations are not meaningful. Instead, assuming a hierarchical interface of classifications, ratios of adjacent roadway functional category group AADT were used to estimate effective green ratios. The ratio of AADT between the two highest categories of Arterials, scaled to a hypothetical 0.5 balance, is used for Arterials. The ratio of the highest category of Collector AADT to the lowest category of Arterial AADT is used for Collectors, again scaled to a hypothetical 0.5 balance. Locals are the default values recommended in the HPMS procedures (HPMS Appendix N). The overall approach is based on, and consistent with, HPMS guidance.

Note that Interstates and Freeways are uninterrupted flow facilities, i.e., they have no traffic control devices, and therefore do not require green ratios. For this calculation, area type definitions are made at the county level and are based on U.S. Census criteria.

Table 21. Estimated Effective Green Ratios (gi/C) by Area Type.

Area Type	Arterials	Collectors	Locals
Rural	0.613	0.448	0.400
Small Urban	0.600	0.487	0.400
Urban	0.508	0.478	0.400

Table 22 incorporates Table 18,

Table 19, Table 20, and Table 21 to produce hourly lane capacities by functional class and area type.

Table 22. Hourly Lane Capacities (vehicles per hour per lane [vphpl]).

Area Type	Roadway Functional Classification				
	Interstate	Freeway	Arterials	Collectors	Local
Rural	2,102	2,102	1,018	744	664
Small Urban	2,271	2,176	954	774	636
Urban	2,328	2,231	753	708	593

The free-flow speed for rural and urban Interstates, Freeways, and Arterials are consistent with HCM guidance (HCM Chapter 10, especially Exhibit 10-5), with appropriate modifications for the aggregation inherent in the virtual link procedure. Minor Collectors and Locals are grouped. In recognition of the aggregation inherent in the process, a lower limit of 30 mph is set on free-flow speed. Free-flow speeds are provided for each of the three area types and seven roadway functional classifications (i.e., 21 HPMS virtual links). Table 23 shows the free-flow speeds.

Table 23. Free-Flow Speeds (mph).

HPMS Area Type	HPMS Roadway Functional Classification					
	Interstate	Freeway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector and Local
Rural	70	70	60	50	40	30
Small Urban	70	60	50	40	35	30
Urban	70	60	40	35	30	30

V/C ratios are generated for each combination of time period (hour), roadway functional classification, area type, and direction using the hourly lane capacities and VMT. The calculations for this procedure are:

- Volume: hourly VMT by direction (discussed in the previous section) is divided by centerline miles, yielding volume for each hour. This procedure is performed for each virtual link (i.e., roadway functional classification and area type combination);
- Capacity: lane miles are divided by centerline miles to produce lanes. Lanes are multiplied by the hourly lane capacities (i.e., adjusted saturation flows) generated by the process described previously, producing hourly capacities. This procedure is performed for each virtual link. (Capacity is the same for each hour and each direction.); and

- V/C ratios: the speed model uses the hourly volumes and capacities to produce hourly, directional v/c ratios for each roadway functional classification and area type combination. These v/c ratios are used to calculate hourly, directional congestion-related delay, and congested speeds (as described in the next section) by functional classification and area type combination.

The congested speed model calculates delay on the link and then applies this delay to the link free-flow speed to calculate the link operational congested speed estimate. The volume/delay equation is:

$$Delay = Min\left[A\, e^{B(\frac{V}{C})}, M \right]$$

Where:

Delay = congestion delay (in minutes/mile);
A & B = volume/delay equation coefficients;
M = maximum minutes of delay per mile; and
V/C = time-of-day directional v/c ratio.

There are two sets of delay model parameters A, B, and M, as shown in Table 24 – one set for high-capacity facilities and one set for low-capacity facilities. The HPMS high-capacity facilities are the Interstate and Freeway classifications.

Table 24. Volume/Delay Equation Parameters.

Facility Category	A	B	M
High-Capacity Facilities (> 3,400 vph one way, e.g., Interstates and Freeways)	0.015	3.5	1.0
Low-Capacity Facilities ($\leq$3,400 vph, e.g., Arterials, Collectors and Locals)	0.050	3.0	2.0

The hourly and 24-hour speed (VMT/VHT) summaries by county and road type were provided electronically (see Appendix A for electronic data descriptions).

ESTIMATION OF SUMMER WEEKDAY OFF-NETWORK ACTIVITY

To estimate the off-network (or parked vehicle) emissions using the mass per activity emissions rates (i.e., mass per SHP, per start, per SHI, and per APU hour), county-level estimates of the SHP, starts, SHI, and APU hours are required by hour and vehicle type (SHI and APU hours are for diesel combination long-haul trucks only). One of the main components of the SHP and starts off-network activity estimation is the analysis year county-level vehicle population. Summaries of the vehicle populations and the 24-hour SHP, starts, SHI, and APU hours estimates are included as Appendix F. Hourly SHP, starts, SHI, and APU hours activity estimates are included with the detailed inventory data provided (see Appendix A).

The county-level vehicle population estimates were developed using the VehPopulationBuild utility. The county-level SHP, starts, SHI, and APU hours of off-network activity were developed using the OffNetActCalc utility. Appendix B contains a description of the utilities.

Estimation of Vehicle Population

Vehicle population estimates are needed to estimate the SHP and starts activity. The 2017 vehicle population estimates were produced for each county (see Appendix F). The vehicle population estimates are a function of vehicle registration data (mid-year TxDMV registration datasets), population scaling factors (where applicable), and vehicle type VMT mix.

For estimating vehicle populations, a historical year is defined as any year where both actual mid-year TxDMV registration data and HPMS VMT data (used in developing population scaling factors) exist. For historical year analyses, mid-year registration data for the year of the inventory analysis are used. For future years, the mid-year registration data for the latest available historical year are used along with analysis year population scaling factors. Since the latest available mid-year TxDMV registration data was 2014, vehicle populations for 2017 were estimated using the procedure for future years.

The VMT mix used to estimate the vehicle population is the aggregate (i.e., all road-type categories) TxDOT district-level weekday VMT mix. The development of the VMT mix was described in more detail in the "Development of Vehicle Type VMT Mix" section. The VMT mix used is summarized in Appendix D.

Historical Vehicle Population Estimates

The county-level vehicle population estimates were initially calculated for the latest available historical year using the county-level, mid-year 2014 TxDMV vehicle registrations and the assigned aggregate VMT mix (see Table 9 and Appendix D). The vehicle population estimation process assumes that all of the non-long-haul SUT category populations for a county are represented in the county vehicle registrations data. This process additionally estimates the long-haul category populations as an expansion of the county registrations. There are three main steps in the vehicle population estimation process: registration data category aggregation, calculation of the vehicle type population factors, and estimation of the county-level vehicle population by vehicle type.

The first step in the vehicle estimation process is the historical year registration data category aggregation. For each county, the vehicle registrations were aggregated into the five categories shown in Table 25.

Table 25. Registration Data Categories.

Registration Data Category	Vehicle Registration Aggregation
1	Motorcycles
2	Passenger Cars (PC)
3	Trucks <= 8.5 thousand (K) gross vehicle weight rating (GVWR) (pounds)
4	Trucks > 8.5 and <= 19.5 K GVWR
5	Trucks > 19.5 K GVWR

The second step is calculating the vehicle type population factors. Using the assigned aggregate VMT mix, population factors were calculated for each vehicle type. For the non-long-haul SUT categories, the population factors were calculated by dividing the vehicle type VMT mix by the summed total of the VMT mix fractions in its associated vehicle registration data category. For example, the LCT_Diesel population factor using the VMT mix is LCT_Diesel/(PT_Gas + PT_Diesel + LCT_Gas + LCT_Diesel). For the long-haul SUTs, the vehicle type population factors were calculated by taking the ratio of the long-haul and short-haul VMT mix values. For example, the SULhT_Gas population factor using SUT mix fractions is SULhT_Gas/SUShT_Gas. Table 26 shows the vehicle registration aggregations and their associated MOVES SUT/fuel types.

Table 26. Vehicle Registration Aggregations and Associated Vehicle Types for Estimating Vehicle Populations.

Vehicle Registration[1] Aggregation	Associated Vehicle Type[2]
Motorcycles	MC_Gas
Passenger Cars (PC)	PC_Gas; PC_Diesel
Trucks <= 8.5 K GVWR (pounds)	PT_Gas; PT_Diesel; LCT_Gas; LCT_Diesel
Trucks > 8.5 and <= 19.5 K GVWR	RT_Gas; RT_Diesel SUShT_Gas; SUShT_Diesel MH_Gas; MH_Diesel IBus_Diesel TBus_Gas; TBus_Diesel SBus_Gas; SBus_Diesel
Trucks > 19.5 K GVWR	CShT_Gas; CShT_Diesel
NA[1]	SULhT_Gas; SULhT_Diesel CLhT_Gas; CLhT_Diesel

[1] The four long-haul SUT/fuel type populations are estimated using a long-haul-to-short-haul weekday SUT VMT mix ratio applied to the short-haul SUT population estimate.

[2] The mid-year TxDMV county registrations data extracts were used (i.e., the three-file data set consisting of: 1 - light-duty cars, trucks, and motorcycles; 2 - heavy-duty diesel trucks; and 3 - heavy-duty gasoline trucks) for estimating the vehicle populations.

The third step is the estimation of the county-level vehicle type population. The non-long-haul vehicle type populations were estimated by applying their vehicle type population factors to the appropriate registration data category. For the CLhT_Gas type, the vehicle population was set to 0. For the remaining three long-haul vehicle types (SULhT_Gas, SULhT_Diesel, and CLhT_Diesel), the vehicle populations were calculated as the product of the corresponding short-haul category vehicle population and the associated long-haul population factor (e.g., SULhT_Gas vehicle population = SUShT_Gas vehicle population x [SULhT_Gas SUT mix fraction/ SUShT_Gas SUT mix fraction]).

Future Vehicle Population Estimates

The process for estimating the county-level population estimates for the future year is a scaling of the latest available historical year estimate described in the previous section. Future year county-level vehicle population scaling factors were used to scale the county-level base 2014 vehicle population estimates to the future analysis year. These future year county-level vehicle population scaling factors were calculated as the ratio of the county-level weekday VMT for the future analysis year to the county-level weekday VMT for the year of the most recent (2014) TxDMV registration data (i.e., vehicle population increases linearly with VMT).

Estimation of SHP

The first activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level estimates of SHP by hour and vehicle type. For each hour, the county-level vehicle type SHP was calculated by taking the difference between the vehicle type total hours minus the vehicle type SHO. Since this calculation was performed at the hourly level, the vehicle type total hours was set equal to the vehicle type population. The SHO was calculated using the link VMT and speeds and the TxDOT district-level vehicle type VMT mixes by MOVES road-type category (see the "Development of Vehicle Type VMT Mix" section for more details). Appendix F includes the 24-hour summaries of the county-level weekday estimates of SHP by hour and vehicle type (hourly summaries were provided electronically to the TCEQ; see Appendix A for electronic data descriptions).

Vehicle Type Total Hours

The vehicle type total hours is typically calculated as the vehicle type population times the number of hours in the time period. Since this calculation was performed at the hourly level, the vehicle type total hours was set equal to the vehicle type population.

Vehicle Type SHO

To calculate VHT (or SHO) for a given link, the VMT was allocated to each vehicle type using the TxDOT district-level vehicle type VMT mixes by MOVES road-type category, which was then divided by the link speed to calculate the link vehicle type SHO. These VMT mixes are the same VMT mixes used to estimate emissions in the emissions estimation process (see Appendix C). This SHO was calculated for each link in a given hour, and aggregated to one value per vehicle type per hour.

Estimation of Starts

The second activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level estimates of starts by hour and vehicle type. The county-level vehicle type starts by hour were calculated as the product of the default, hourly, starts per vehicle by vehicle type and the associated analysis year county-level vehicle type populations. Appendix F includes the 24-hour summaries of the county-level vehicle type starts by hour (hourly summaries were provided electronically to the TCEQ; see Appendix A for electronic data descriptions).

For the hourly starts per vehicle, the MOVES defaults were used. The MOVES activity output was used to estimate the hourly starts per vehicle for a MOVES weekday run by dividing the MOVES start output by the MOVES vehicle population output. These MOVES national default starts per vehicle do not vary by year, but they do vary by MOVES day type. For this seasonal weekday analysis, the MOVES national default weekday starts per vehicle were used.

Estimation of SHI and APU Hours

The remaining activity measures needed to estimate the off-network emissions using the mass per activity emissions rates are the hourly, county-level heavy-duty diesel truck (SUT 62, fuel type 2 [CLhT_Diesel]) emissions-producing hotelling activities (i.e., truck main engine idling and diesel APU use). During hotelling, the truck's main engine is assumed to be in extended idle mode or its diesel auxiliary power unit is in use, or it is using electric power or no power. Hotelling hours were first estimated followed by estimation of the SHI and diesel APU hours components of hotelling hours. The following discussion of SHI and APU hours estimation procedures applies only to CLhT_Diesel vehicles, unless stated otherwise.

The hotelling activity estimates were based on information from a the TCEQ extended idling study which produced 2017 winter weekday extended idling estimates for each Texas county. Hotelling scaling factors for the analysis year scenario (2017 summer weekday) were applied to the base 2017 winter weekday hotelling values from the study to estimate the 24-hour hotelling. Hotelling hourly factors were then applied to allocate the 24-hour hotelling to each hour of the day. To ensure valid hourly hotelling values were used in the emissions estimation, the hourly hotelling hours were compared to the hourly SHP (i.e., hourly hotelling values cannot exceed the hourly SHP values). SHI and APU hours factors were then applied to the hotelling hours to produce the hourly SHI and APU hours activity. Appendix F incudes the 24-hour summaries of the county-level estimates of hotelling hours, SHI, and APU hours (hourly summaries were provided electronically to the TCEQ; see Appendix A for electronic data descriptions).

Hotelling Scaling Factors

To estimate the county-level 24-hour hotelling, county-level hotelling scaling factors were developed for the 2017 summer weekday. These scaling factors were produced using county-level link VMT and speeds and VMT mixes for the hotelling base scenario (2017 winter weekday) and for the 2017 summer weekday analysis scenario. The 2017 winter weekday link-level VMT and speeds were developed similarly to the 2017 summer weekday link-level VMT and speed data except using 2017 winter weekday county VMT control totals and winter weekday hourly travel factors. The vehicle type VMT mixes were the same VMT mixes used to estimate emissions in the emissions estimation process.

For each link in the 2017 winter weekday link-level VMT and speeds dataset, the link VMT was allocated to CLhT_Diesel using the VMT mix. This VMT allocation was performed for each link and hour in the base, 2017 winter weekday link VMT and speeds dataset. The individual link VMT was then aggregated by hour to produce the hourly and 24-hour 2017 winter weekday CLhT_Diesel VMT estimate. The 2017 summer weekday hourly and 24-hour CLhT_Diesel VMT estimates were calculated in the same manner using the 2017 summer weekday link data and VMT mix. The county-level 24-hour hotelling scaling factors were calculated by dividing the 24-hour VMT estimate for summer weekday by the estimate for winter weekday.

Hotelling Hourly Factors

Hotelling hourly factors were used to allocate county-level, 24-hour, hotelling hours to each hour of the day. These hotelling hourly factors were calculated as the inverse of the summer weekday hourly VHT fractions. The hourly VHT fractions were first calculated using the hourly VHT from the SHP estimation process (VHT = SHO). The inverses of these hourly VHT fractions were calculated and then normalized across all hours to produce the county-level, hotelling hours hourly distribution for the summer weekday.

Hotelling by Hour Estimation

The initial 2017 summer weekday hotelling by hour was calculated by multiplying the 24-hour 2017 winter weekday hotelling hours by the 2017 summer weekday hotelling scaling (or adjustment) factor and by the summer weekday hotelling hourly factors. A comparison was then made between hourly hotelling and hourly SHP estimates. For each hour where the initial hotelling hours were greater than the SHP, the final hotelling hours estimate was set equal to the SHP, otherwise the initial hotelling hours estimate was set as the final value. All calculations (scaling factors, hotelling hourly factors, and hotelling by hour calculations) were performed by county.

SHI and APU Hours Estimation

The hourly, county-level, hotelling estimates were factored to produce the SHI and APU hours activity components using aggregate extended idle mode and aggregate APU mode fractions. The hotelling hours estimate for each hour was multiplied by the SHI fraction to calculate the hourly SHI, and by the APU fraction to calculate the hourly APU hours.

The aggregate SHI and the APU fractions were estimated using model year travel fractions (based on source type age distribution and relative mileage accumulation rates used in the MOVES runs) and the updated MOVES hotelling distributions shown in Table 27.[12] The associated travel fractions were applied to the appropriate extended idle and APU operating mode fractions (of the hotelling operating mode distribution) by model year and summed within each mode to estimate the aggregate (across model years) individual SHI and APU fractions. (The sum of the resulting SHI and APU fractions, when subtracted from 1.0, leaves the portion of hotelling hours in which trucks were using electric power or using no power.)

[12] Population and Activity of On-road Vehicles in MOVES201X (page 87 of unpublished report), https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=328870.

Table 27. Hotelling Activity Distributions by Model Year.

First Model Year	Last Model Year	Operating Mode Fraction by ID and Name			
		200	201	203	204
		ExtendIdling	Diesel Aux	Battery AC	APU Off
1960	2009	0.80	0	0	0.20
2010	2020	0.73	0.07	0	0.20
2021	2023	0.48	0.24	0.08	0.20
2024	2026	0.40	0.32	0.08	0.20
2027	2050	0.36	0.32	0.12	0.20

ESTIMATION OF SUMMER WEEKDAY EMISSIONS RATES

TTI developed the emissions rates needed for the on-road mobile source summer weekday emissions inventories according to TTI's detailed MOVES rates-per-activity, county-level, link-based, method. On-road mobile emissions rates data from the EPA's emissions factor model, MOVES2014a,[13] together with TTI rates post-processing utilities, RatesCalc and RatesAdj, were used to produce rates in the form needed for input to the TTI external inventory calculation utility, EmsCalc.

The emissions rates were developed based on TTI's *TTI Emissions Inventory Utilities User's Guide* [14] and the EPA's MOVES inventory development *Technical Guidance*[15] and *User's Guide.*[16] The TTI MOVES data post-processing utilities used to produce the databases of rates look-up tables are additionally described, along with other TTI inventory process utilities, in Appendix B of this report.

The general process involved setting up and executing MOVES emissions rates mode runs to produce the emissions and activity data needed for the development of on-road mobile source, county-level emissions rates. For the initial post-processing step, TTI's on-road rates look-up table post-processor, RatesCalc, was run to produce rates look-up tables from the MOVES data. The TTI RatesAdj utility was then run to produce the final rates look-up tables by dropping pollutants not needed and making adjustments where required. Using this process, on-road rates

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[13] Software (MOVES2014a November 2016 release) and database (MOVESDB20161117) from http://www.epa.gov/otaq/models/moves/index.htm. EPA's November 2016 MOVES2014a update is, for practical purposes, the latest on-road release, producing results equivalent to MOVES2014b (verified by TTI). (EPA released MOVES2014a November 2015 and updated it December 2015, November 2016, and December 2017. The December 2017 MOVES2014a release only corrected a non-road mobile post-processing script. EPA released MOVES2014b August 2018 (and a December 2018 update). MOVES2014b improves the non-road component and updates chemical mechanism outputs neither of which are applicable to this inventory analysis.

[14] TTI's MOVES2014a-compatible inventory estimation utilities are detailed in the document, *TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUTL User's Guide,* TTI, August 2016.

[15] *MOVES2014, MOVES2014a, and MOVES2014b Technical Guidance: Using MOVES to Prepare Emissions Inventories for Sate Implementation Plans and Transportation Conformity*, EPA, August 2018.

[16] *MOVES2014a User Guide,* EPA, November 2015.

look-up tables were produced from each MOVES run in the form needed for input to the EmsCalc utility external inventory calculations.

For the external inventory calculations, the method requires that all rates be in terms of mass per unit of activity, as opposed to the off-network rates of mass per vehicle, which is the only output option available for off-network "parked vehicle" evaporative emissions output by MOVES. Table 28 summarizes the form of rates produced for the external inventory calculations (presented in a previous section, but provided here again for convenience).

Table 28. Emissions Rates by MOVES Emissions Process and Activity Factor.

Process (Process ID)	Activity[1]	Emissions Rates[2]
Running Exhaust (1)	VMT	mass/mile (mass/mi)
Crankcase Running Exhaust (15)	VMT	mass/mi
Brake Wear (9)	VMT	mass/mi
Tire Wear (10)	VMT	mass/mi
Start Exhaust (2)	starts	mass/start
Crankcase Start Exhaust (16)	starts	mass/start
Extended Idle Exhaust (90)	SHI	mass/shi
Crankcase Extended Idle Exhaust (17)	SHI	mass/shi
Auxiliary Power Exhaust (91)	APU Hours	mass/APU hour
Evaporative Permeation (11) Evaporative Fuel Vapor Venting (12) Evaporative Fuel Leaks (13)	VMT, SHP	mass/mi, mass/shp

[1] VMT, SHP, vehicle starts, and emissions-producing hotelling activity (SHI and APU hours) are the basic activity factors. SHI and APU hours are for combination long-haul trucks only.
[2] All mass per activity rates shown are available in the MOVES rate mode table output, except for mass/shp, which is produced using the TTI RatesCalc utility.

MOVES Inputs, Outputs, and Post-Processing

The MOVES model is equipped with default modeling values for the range of conditions that affect emissions factors. MOVES defaults may be replaced by alternate input data sets that better reflect local scenario conditions. Where available and consistent with the methodology, local data were used in place of MOVES default data via the MOVES Run Specification input file (RunSpec or MRS) and MOVES CDB. (The MRS files, CDBs, and MOVES default database provide the input data tailored for each local scenario.)

Local data were developed to reflect county June through August period weather conditions, summer fuel properties for the region, and county vehicle age distributions. No I/M program is required in the TLM counties, so no I/M was modeled. For the vehicle populations, VMT activity and various travel-related factors input data to MOVES, the MOVES defaults were used, which is basic to the emissions rates method (i.e., emissions rates produced via post-processing were externally multiplied by the actual local VMT and off-network activity estimates, detailed in the previous sections, to calculate emissions external to MOVES).

There was one RunSpec and one CDB required per county per MOVES run. Each RunSpec was designed to produce a separate, corresponding MOVES output database (i.e., one output database per run). For the post-processing corresponding to each MOVES run, RatesCalc first processed the MOVES data into one interim "ratescalc" output database. The RatesAdj utility processed the RatesCalc output (filtered and adjusted the emissions rates as needed) loading the resulting final rates into one database, for each MOVES run, for subsequent input to TTI's EmsCalc inventory calculation utility. All counties require TxLED. The final diesel vehicle NO_x emissions rates were adjusted to include the effects of TxLED.

MOVES set-ups and runs were executed and the results were post-processed to produce county-level, summer weekday, activity-based emissions rates of the desired pollutants and processes. The emissions rates were estimated by speed (for miles-based rates), process, hour, MOVES road type, SUT, and fuel type.

Summary of Control Programs Modeled

Table 29 shows the control measures modeled.

Table 29. Emissions Control Strategies and Modeling Approaches.

Strategy	Approach
Federal Motor Vehicle Control Program (FMVCP) Standards	MOVES Defaults – Full FMVCP available in MOVES was modeled.
Reformulated Gasoline (RFG)	Not applicable.
Conventional Gasoline[1]	Local inputs to MOVES – TTI based gasoline formulations on the TCEQ's 2017 summer season, retail outlet, gasoline survey data.
Diesel Fuel[2]	Sulfur: Local inputs to MOVES – TTI used average diesel sulfur content estimate based on data from the TCEQ's summer 2017 statewide retail outlets diesel survey (estimate was within the federal ultra low sulfur diesel standard). TxLED: TTI post-processed diesel vehicle NO_x emissions factors using calendar year 2017 average NO_x reduction factors (based on 4.8% and 6.2% reductions for 2002 and later, and 2001 and earlier model years, respectively).
Inspection/Maintenance (I/M) Program	Not applicable.

[1] All five TLM area counties are in the same fuel region (Texas Regional Low RVP Program region where a 7.8 psi RVP limit with no RVP waiver for oxygenate required); accordingly, fuel property estimates based on sample data from this region were used for all TLM counties.

[2] Consistent with the benefit information described in the EPA *Memorandum on Texas Low Emission Diesel Fuel Benefits,* EPA, September 2001. All TLM counties required TxLED fuel and were modeled with TxLED effects.

MOVES Emissions Factor Aggregation Levels

The MOVES model produces results at different aggregation levels that may be specified in the MRS. The detailed, hourly, link-based inventory method required MOVES weekday day type rates at the following MOVES output detail level:

- Up to 13 source types (i.e., vehicle types);
- Up to five fuel types;
- Up to five road types (four actual MOVES road categories and "off-network");
- Each of the 24 hours in a day;
- 16 speed bins (only in miles-based rate tables);
- Up to 156 pollutants; and
- Up to 14 on-road processes.

The vehicle fleet was modeled as powered by the predominant on-road fuels of gasoline and diesel only (alternative fuels were considered *de minimis*). The five road type categories in MOVES are Rural Restricted Access, Rural Unrestricted Access, Urban Restricted Access, Urban Unrestricted Access, and Off-Network (this one is not actually a road type, but a location for parked vehicle activity). The rates for each of the four actual road types are indexed by the 16 MOVES speed bin average speeds: 2.5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 mph.

MOVES Run Specification Input Files

The MOVES Run Specification (MRS) is a file (in XML format) that defines the place, time, road categories, vehicle and fuel types, pollutants and emissions processes, and the overall scale and level of output detail for the modeling scenario. TTI created an MRS for one county using the MOVES graphical user interface (GUI), converted this MRS to a template, and used it as a base from which to build all the MRSs needed.

Table 30 describes the MRS selections TTI used. Further details on the selections are provided after the table.

Table 30. Selections by MOVES Graphical User Interface Panel.

<table>
<tr><th>Navigation Panel</th><th>Detail Panel[1]</th><th colspan="3">Selection</th></tr>
<tr><td>Scale[1]</td><td>Model; Domain/Scale;
Calculation Type</td><td colspan="3">On-Road; County;
Emissions Rates</td></tr>
<tr><td>Time Spans[1]</td><td>Time Aggregation Level;
Years – Months – Days – Hours</td><td colspan="3">Hour;
2017[1] - July – Weekday - All</td></tr>
<tr><td>Geographic Bounds[1]</td><td>Region;
Selections;
Domain Input Database</td><td colspan="3">Zone and Link;
<COUNTY>;[1]
<COUNTY INPUT DATABASE (CDB) NAME>[1]</td></tr>
<tr><td rowspan="14">On-Road Vehicle Equipment</td><td rowspan="14">SUT/Fuel Combinations</td><td>SUT</td><td>Gasoline</td><td>Diesel</td></tr>
<tr><td>Motorcycle</td><td>X</td><td>-</td></tr>
<tr><td>Passenger Car</td><td>X</td><td>X</td></tr>
<tr><td>Passenger Truck</td><td>X</td><td>X</td></tr>
<tr><td>Light Commercial Truck</td><td>X</td><td>X</td></tr>
<tr><td>Intercity Bus</td><td>-</td><td>X</td></tr>
<tr><td>Transit Bus</td><td>-</td><td>X</td></tr>
<tr><td>School Bus</td><td>X</td><td>X</td></tr>
<tr><td>Refuse Truck</td><td>X</td><td>X</td></tr>
<tr><td>Single Unit Short-Haul Truck</td><td>X</td><td>X</td></tr>
<tr><td>Single Unit Long-Haul Truck</td><td>X</td><td>X</td></tr>
<tr><td>Motor Home</td><td>X</td><td>X</td></tr>
<tr><td>Combination Short-Haul Truck</td><td>X</td><td>X</td></tr>
<tr><td>Combination Long-Haul Truck</td><td>-</td><td>X</td></tr>
<tr><td>Road Type</td><td>Selected Road Types</td><td colspan="3">Off-Network –
Rural Restricted Access – Rural Unrestricted Access –
Urban Restricted Access – Urban Unrestricted Access</td></tr>
<tr><td>Pollutants[2] and Processes</td><td>VOC; CO; NO_x; SO_2; NH_3; Atmospheric CO_2; PM_{10} Total Exhaust, Brakewear, Tirewear; $PM_{2.5}$ Total Exhaust, Brakewear and Tirewear; and the MOVES HAPs</td><td colspan="3">Dependent on pollutant:
Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Crankcase Extended Idle Exhaust, Evap Permeation, Fuel Vapor Venting, Fuel Leaks, Brakewear, Tirewear</td></tr>
<tr><td>Manage Input Data Sets</td><td>Additional Input Database Selections</td><td colspan="3">None</td></tr>
<tr><td>Strategies</td><td>Rate Of Progress</td><td colspan="3">Not Applicable</td></tr>
<tr><td>General Output</td><td>Output Database;
Units;
Activity</td><td colspan="3"><MOVES OUTPUT DATABASE NAME>;[1]
Pounds, KiloJoules, Miles;
Hotelling Hours, Population, Starts (pre-selected)</td></tr>
<tr><td>Output Emissions Detail</td><td>Always;
For All Vehicles/Equipment;
On Road</td><td colspan="3">Time: Hour – Location: Link – Pollutant;
Fuel Type, Emissions Process;
Road Type, Source Use Type</td></tr>
<tr><td>Advanced Performance Measures</td><td>Aggregation and Data Handling</td><td colspan="3">Checked the “clear BaseRateOutput after rate calculations” box</td></tr>
</table>

[1] County scale allows only one county and year per run. County FIPS code and year were included in the MRS file names and in the CDB names and output database names.

[2] Pollutants shown were included in the externally-calculated inventory output. Some of these pollutants require other “base” pollutants (not listed in the table) to be selected in the MRS (VOC requires Total Gaseous Hydrocarbons and Non-Methane Hydrocarbons, Atmospheric CO_2 requires Total Energy Consumption, $PM_{2.5}$ includes several subcomponents, e.g., elemental carbon, organic carbon, sulfate).

Scale, Time Spans, and Geographic Bounds

The MOVES Domain/Scale "County" was selected as required for SIP inventory estimates. The MOVES Calculation Type "Emissions Rates" was selected for MOVES to produce the emissions rates with speed bin indexing, as needed for the link-based inventory estimation process.

The Time Spans parameters were specified to provide the most detail available, which is the hourly aggregation level, for all hours of the day, for the selected year, month, and day type. One each "Years" (2017), "Months" (July), and "Days" (Weekdays) were selected.

Under Geographic Bounds for the County Domain Scale, only one county may be selected. The local CDB containing the calendar year scenario-specific input data for the county was specified as the County Domain Input Database, and under Region, "Zone & Link" was selected as required for the emissions rates calculation type. With these required set-ups, one county, one year, one day type, 24 hourly periods, and 16 (speed bin) average speeds were modeled per run.

On-Road Vehicle Equipment and Road Type

The local VMT mixes developed for the study define the vehicle type combinations included in the MOVES runs. The VMT mixes specify the vehicle fleet as the 22 gasoline and diesel SUTs designated as "on-road vehicle equipment" selections in Table 30. These SUT/fuel type combinations were chosen in all the MOVES RunSpecs. The MOVES default fuel engine fractions were additionally replaced (via the MOVES Alternate Vehicle Fuel and Technology [AVFT] table, discussed later) with local input data consistent with the vehicle type combinations selected.

All five MOVES road type categories were selected (the "provide separate ramps output" box is not active when using emissions rates mode).[17]

Pollutants and Processes

The required pollutants were previously listed in Table 6, Table 7, and Table 8. In addition to these required pollutants within the scope of the inventory, some of the required pollutants had pre-requisite pollutants that needed to be selected (i.e., pollutants calculated as a function of another MOVES pollutant). For example, non-methane hydrocarbons and total gaseous hydrocarbons are needed to model VOC; total energy consumption (TEC) is needed for CO_2; and Composite – NonECPM (non-elemental carbon), H_2O (aerosol), and sulfate must be selected to model Primary Exhaust $PM_{2.5}$ - Total. All of the associated on-road processes available by the selected pollutants were included, with the exception of the two refueling emissions processes, which are in the area sources major source category.

Manage Input Data Sets and Strategies

The Manage Input Datasets feature allows alternate inputs other than those included in the CDB. No additional inputs were included via the Manage Input Datasets panel.

The Strategies feature is for modeling an alternate control program option, which was not applicable to this inventory analysis.

[17] The MOVES "separate ramps" feature is not available for MOVES emissions rates mode.

Output

The output units were pounds, kilojoules, and miles. The activity categories were pre-set by MOVES rates mode for inclusion in the output database. The selected output detail level was by hour, link (in MOVES rates mode "link" is the combination of county, road type, and speed bin), pollutant, process, road type, SUT, and fuel type.

Appendix A lists the electronic data files provided in support of this analysis, which includes the MRSs used.

MOVES County Input Databases

The locality-specific input data for the county scale runs were entered through the CDB.

TTI developed procedures to accommodate building and checking CDBs for large scale emissions inventory estimation projects. The basic procedure was to write a MySQL script to produce one county scenario CDB and convert it to a template from which all of the CDB scripts were built. The scripts were then run in batch mode to produce all CDBs for the analysis.

Data for populating the CDBs were first prepared in the form of text files and/or MySQL databases (e.g., for local fuels, weather data), and some values were provided directly in the CDB builder MySQL script. Any default data used was selected from the MOVES default database, MOVESDB20161117. After running the scripts to produce the CDBs, a CDB checker utility written by TTI was run to verify that all CDB tables were built and populated as intended.

Table 31 provides an outline and brief description of the CDBs, followed by discussion of the development of the local data and the defaults used in the CDBs. Unless otherwise stated, the CDB table data applies to all counties.

Table 31. CDB Input Tables.

MOVES Input Table	Data Category	Notes
year	Time	Designates analysis year as a base year (base year means that activity inputs for the analysis are supplied rather than forecast by the model).
state	Geography	Identifies the state (Texas) for the analysis.
county	Geography/ Meteorology	Specifies the county, local altitude, and barometric pressure (base year 2017 annual average data were provided by the TCEQ).
zonemonthhour[1]	Meteorology	Local, hourly temperature, and relative humidity for the county (2017 data for both summer and winter seasons, provided by the TCEQ).
roadtype[2]	Activity	Lists the MOVES road types and associated ramp activity fractions. Road type ramp fractions were set to 0.
hpmsvtypeyear[3]	Activity	Used MOVES default national annual VMT by HPMS vehicle type.
roadtypedistribution[3]		Used MOVES default road type VMT fractions.
monthvmtfraction[3]		Used MOVES default month VMT fractions.
dayvmtfraction[3]		Used MOVES default day VMT fractions.
hourvmtfraction[3]		Used MOVES default hour VMT fractions.
avgspeeddistribution[3]		Used MOVES default average speed distributions.
sourcetypeyear[3]	Fleet	Used MOVES default national SUT populations.
sourcetypeagedistribution	Fleet	Local SUT age fractions estimated using TxDMV mid-year vehicle registrations and MOVES defaults, as needed. Used TxDMV latest available (2014) vehicle registrations and MOVES defaults consistent with TxDMV data year.
avft	Fleet	Local SUT fuel fractions estimated using TxDMV vehicle registration data, consistent with the data used in the sourcetypeagedistributions, and defaults where needed. Only gasoline and diesel were included, consistent with local VMT mix.
zone	Activity	Start, idle, and SHP zone allocation factors. County = zone, and all factors were set to 1.0 (required for county scale analyses).
zoneroadtype	Activity	SHO zone/roadtype allocation factors. County = zone, and all factors were set to 1.0 (required for county scale analyses).
fuelsupply[1]	Fuel	Fuel supply market shares were set to specify one conventional gasoline and one diesel fuel formulation, per seasonal period (summer and winter were included).
fuelformulation[1]	Fuel	Local gasoline and diesel formulations prepared by TTI. Summer gasoline and all seasons diesel based on the TCEQ summer 2017 gasoline and diesel survey data, and winter gasoline based on MOVES defaults.
imcoverage	I/M	Not applicable (empty table was included).
countyyear	Stage II	Not applicable in analysis (affects refueling emissions), but was included with control program adjustments set to zero.
hotellingactivitydistribution	Activity	Used the newly updated distribution from the TCEQ's 2017 long-haul truck hotelling/idling study.

[1] Meteorological and fuels input data were included for both summer and winter seasons.
[2] In MOVES rates mode, "ramp road type" rates are not available.
[3] Use of a default set of VMT activity, various travel-related factors, and vehicle population inputs for all MOVES runs is basic to the inventory method, e.g., MOVES default activity is normalized in the calculated rates for applicable processes, and actual local activity estimates are used in the external inventory calculations.

Year, State, and County Inputs to MOVES

The year, state, and county tables were populated with data identifying the year, state, and county of the run.

The yearID field of the "year" table was populated with the analysis year value, and the year was set as a base year (to specify that certain user-input fleet and activity data were to be used, rather than forecast by MOVES during the model runs). As part of designating the appropriate fuel supply for the modeling scenario, the fuelyearID in the year table was additionally set to the analysis year.

StateID "48" (Texas) was inserted in the state table. In addition to identifying the county of analysis, the county table contains barometric pressure and altitude information (discussed further with other meteorological inputs). The county data were selected from a prepared local "meteorology" database containing tables of weather data records (i.e., "county" and "zonemonthhour" tables) for the analysis.

Roadtype Inputs to MOVES

The MOVES model contains "ramp" emissions rates, but not an (activated) individual road type for separate ramps output (when using MOVES in rates mode). In the roadtype table, MOVES provides a field "rampFraction" for including a fraction of estimated ramp activity as a fraction of SHO on each of the MOVES road types. For this analysis, the MOVES default roadtype table data were used, except the ramp fractions were set to zero (i.e., 100 percent of activity on each MOVES road type was based on the road type drive cycles assigned to that road type by MOVES, exclusive of ramp activity).

Activity and Vehicle Population Inputs to MOVES

The VMT activity, various travel-related factors and vehicle population input parameters under the methodology use the MOVES defaults. The tables are: hpmsvtypeyear, roadtypedistribution, monthvmtfraction, dayvmtfraction, hourvmtfraction, avgspeeddistribution, and sourcetypeyear. Data for all of these tables were selected and inserted from the MOVES default database.

The zone and zoneroadtype tables contain zonal sub-allocation activity factors. For county scale analyses, county is equal to zone, therefore these allocation factors were set to 1.0.

Age Distributions and Fuel Engine Fractions Inputs to MOVES

The locality-specific inputs of vehicle age and fuel type fractions by model year, under the SIP county-level inventory procedures, consist of county-level age distributions and statewide gasoline and diesel fractions (MOVES fuel engine fractions). The age distributions and fuel engine fractions inputs were calculated and written to text files in preparation for loading the data into the appropriate CDB input tables: the sourcetypeagedistribution table for age distributions, and the AVFT table for fuel engine fractions. The MOVESfleetInputBuild utility was used to produce local sourcetypeagedistribution and AVFT inputs to MOVES in the required formats (see utility description in Appendix B), and MySQL scripts were used to populate the CDB input tables.

The age distributions and fuel engine fractions were based on TxDMV mid-year county registrations data and MOVES model defaults, where needed. The fuel engine fractions were developed consistent with the local VMT mix estimate (i.e., the local fuel engine fractions estimates reflect no compressed natural gas [CNG] vehicles, no E-85 fuel type, and no gasoline transit buses, consistent with the local VMT mix). Locality-specific SUT age distributions were produced based on the TxDMV county vehicle registration category aggregations, consistent with the vehicle registration category aggregations of the VMT mix. Appendix G includes the age distributions and fuel engine fractions summaries.

Table 32 summarizes the data sources and aggregation levels used to estimate the local sourcetypeagedistribution and AVFT inputs to MOVES.

Table 32. Data Sources and Aggregations for Age Distributions and Fuel/Engine Fractions.

SUT Name	SUT ID	TxDMV Category[1] Aggregations for Age Distributions and Fuel/Engine Fractions	Geographic Aggregation for Age Distributions	Geographic Aggregation for Fuel/Engine Fractions[2]
Motorcycle	11	Motorcycles	County	NA – 100% gasoline, no Fuel/Engine Fractions
Passenger Car	21	Passenger Cars	County	Modified MOVES default[2]
Passenger Truck	31	Total Trucks<=8500	County	
Light Commercial Truck	32	Total Trucks<=8500	County	
Single-Unit Short-Haul Truck	52	>8500+ >10000+ >14000+>16000	MPO Region	Texas Statewide
Single-Unit Long-Haul Truck	53	>8500+ >10000+ >14000+>16000	Texas Statewide	Texas Statewide
Refuse Truck	51	MOVES default consistent with year of local data	MOVES default	MOVES default
Motor Home	54			MOVES default
Intercity Bus	41			MOVES default
Transit Bus[2]	42			Modified MOVES default[2]
School Bus	43			MOVES default
Combination Short-Haul Truck	61	>19500+ >26000+ >33000+ >60000	Region	Texas Statewide
Combination Long-Haul Truck	62	>19500+ >26000+ >33000+ >60000	Texas Statewide	NA – 100 % diesel, no Fuel/Engine Fractions

[1] TxDMV mid-year 2014 (latest available used for 2017) county vehicle registrations data (i.e., three-file data set: composite fuel light-duty categories; heavy-duty gasoline by eight weight categories; and heavy-duty diesel by eight weight categories) were used for developing local inputs (weights are GVWR in units of lbs.). The MOVES2014a model default age distributions were from the MOVESDB20161117 database.

[2] Consistent with the local vehicle type VMT mix, MOVES fuel engine fractions for light-duty categories were revised to exclude E-85, and for transit buses were revised to exclude CNG and gasoline components. MOVES default fuel engine fractions were taken from the MOVESDB20161117 sample vehicle population table.

Local Meteorological Inputs to MOVES

The meteorological input data are entered in the CDB "county" table (barometric pressure and altitude) and "zonemonthhour" table (temperature and relative humidity).

The 2017 meteorological input data package from the TCEQ included averages by different periods. TTI used the seasonal averages for hourly temperature and hourly relative humidity inputs (both summer and winter were needed), and used the annual averages for barometric pressure input. The seasonal hourly averages used are from the three-month groups of June, July, August (summer) and December, January, February (winter). The annual average barometric pressure is the average for all hours of the year. The TCEQ developed the county inputs using the hourly data from numerous weather stations within each county. Altitude was set to "low" for all counties. Appendix H provides summaries of the summer and winter temperatures and relative humidity, and the annual average barometric pressure input values used.[18] The CDBs were populated with inputs for both summer and winter.

Fuels Inputs to MOVES

The context for this fuels inputs development section is the entire Texas AERR inventories project (i.e., covering all Texas counties by region). Both summer and winter data are discussed – winter input values were additionally needed for the annual emissions estimation described in a later section.

The local fuel property and market share inputs to MOVES county scale runs are entered in the CDB fuelsupply and fuelformulation tables. The fuel supply table provides regional market shares for each fuel formulation by year and month (which may represent a season). Fuel formulations include the estimated fuel property values. The fuel supply of a region, year, and month may include multiple sub-types for each fuel type, but the sub-type market shares must sum to 1.0 for each fuel type. Of the five on-road MOVES fuel types, Texas statewide emissions inventory analyses currently include the predominant two – gasoline (conventional gasoline [CG] and RFG) and diesel (conventional), with other fuel types considered *de minimis*.

General Approach – TTI develops summer and winter fuels inputs based on local, retail outlet, survey data. Where local survey data are not available MOVES default data are typically used.

TTI estimates fuel properties by six Texas fuel regions (listed in Table 33). The fuel types in the local MOVES fuel supply inputs must be consistent with the fuel types in the local MOVES avft inputs (fuel fractions by model year – see Table 32) and the local vehicle type VMT mixes (VMT fractions by source type, fuel type, and road type, used in external, link-level inventory calculations – see Table 9 and Appendix C). Alternative fuels are treated as *de minimis*. For historical analysis years, local survey data from the analysis year (or nearest year available, if analysis year-specific data are not available) are typically used for all MOVES fuelformulation inputs.

[18] The TCEQ provided the meteorological inputs to MOVES in compressed files downloadable at ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/met/2017/. The TCEQ developed these 2017 inputs to MOVES as averages within several periods, including month, three-month group season, and year.

In cases where local survey data are not available (as is the case for Texas winter CG) appropriate MOVES defaults are typically used. Renewable fuel volume levels affected by the federal Renewable Fuel Standard (RFS) are currently based on the available local survey data.[19]

The local fuel survey information available consists of the TCEQ's, statewide gasoline and diesel summer surveys performed on a three-year cycle (latest is 2017); and summer and winter RFG surveys for Texas, performed every year as part of EPA's RFG compliance program. The TCEQ CG data are used to estimate summer CG formulations and the TCEQ diesel data are used to estimate a conventional diesel formulation for the state for all seasons. EPA RFG data are processed separately to produce Dallas and Houston, summer and winter RFG formulations.

The six fuel regions in MOVES for Texas are generally in line with the applicable Texas fuel rule jurisdictions. Table 33 describes the fuel regions. Appendix A includes a list of all counties with their associated fuel regions.

Table 33. Texas Fuel Region Descriptions.

Label	MOVES fuelregionid	Counties	Description[1]
R1	300000000	132	Federal 9.0 RVP limit (waiver for E10), minus 11 southern counties labeled as R6
R2	178010000	95	TxLED; state 7.8 RVP limit (no waiver for E10)
R3	370010000	1	El Paso 7.0 RVP (no waiver for E10)
R4	1370011000	12	TxLED; RFG (separate DFW and HGB formulations)
R5	178000000	3	TxLED; federal 7.8 RVP limit (waiver for E10)
R6	100000000	11	Same as R1, but different distribution network

[1] E10 is gasoline (CG or RFG) blended with a nominal 10 percent by volume of ethanol.

The fuel area labels R1 through R6 represent five summertime gasoline rules comprising all Texas counties. Consistent with MOVES, however, the 143 Texas federal 9.0 RVP limit rule counties are subdivided into two areas (i.e., R1 and R6), where 11 counties in the south end of Texas (labeled as R6) are treated as a separate group.[20] The R1, R3, and R6 regions are comprised solely of non-TxLED counties and the R2, R4, and R5 regions include all TxLED counties.

TTI produced and combined all the estimated fuelsupply and fuelformulation inputs (2017 summer and winter for all six regions) in a single database, for use in creating the MOVES CDBs for the emissions rate runs. MySQL scripts were written to produce CDBs containing the fuels input data for both seasons.

[19] Constraints on the fuel market to accommodate RFS-mandated increasing renewable fuel volumes (e.g., ethanol, biodiesel) have required EPA to propose reductions in total renewable fuels below statutory volumes. With observed and potential variability in annual renewable fuel volume targets due to such market constraints, latest observed renewable fuel volumes in local survey-based estimates are considered reasonable. Ethanol and biodiesel blends are based on the available Texas fuel surveys, which currently indicate statewide saturation of E10 gasoline (both CG and RFG blended with ethanol volumes of approximately 10%) and no biodiesel.

[20] Per EPA OTAQ fuel distribution network analysis (reflected in MOVES), which identified these 11 South Texas counties as part of a different supply network.

The MOVES2014a fuelformulation table fuel ID and fuel property fields include:

- fuelFormulationID (unique local ID for each fuel, different from MOVES default IDs);
- fuelSubtypeID (MOVES ID specifying the subtype of the fuel type);
- RVP (pounds per square inch [psi]);
- sulfurLevel (parts per million [ppm]);
- ETOHVolume (volume percent);
- MTBEVolume (volume percent);
- ETBEVolume (volume percent);
- TAMEVolume (volume percent);
- aromaticContent (volume percent);
- olefinContent (volume percent);
- benzeneContent (volume percent);
- e200 (vapor percent at 200 degrees Fahrenheit);
- e300 (vapor percent at 300 degrees Fahrenheit);
- T50 (degrees Fahrenheit at 50 percent vapor); and
- T90 (degrees Fahrenheit at 90 percent vapor).

Although not included in the previous fuel property fields list, BioDieselEsterVolume, CetaneIndex, and PAHContent are additionally fuelformulation table fields, but are not used (and currently are populated with NULL values).

The MOVES2014a fuelsupply table fields include:

- fuelRegionID (the six IDs for Texas are shown in Table 33);
- fuelYearID (the year in which the fuel supply occurs – same as the analysis year);
- monthGroupID (1 [used January for winter season] and 7 [used July for summer season]);
- fuelFormulationID (for the specified fuelRegionID, fuelYearID, and monthGroupID); and
- marketShare (value from 0 to 1.0 for the fuelformulationID).

Data Sources – The TCEQ provided the summer 2017 Texas statewide, retail outlet, fuel survey data summaries, for which the information on local CG and diesel fuel were used. The survey includes gasoline samples by grade and diesel samples from each of 92 locations across

Texas.[21] EPA provided summer and winter 2017, retail outlet, RFG survey data summaries for Dallas and Houston RFG areas. Additionally, MOVESDB20161117 defaults were used, as needed, and Energy Information Association (EIA) gasoline sales volume statistics for Texas were used.

Development of Gasoline Fuel Formulations Inputs **– TTI used the standard procedure that involved calculating average fuel properties by fuel grade within each region, and overall averages as a weighting of the individual fuel grade results. The weighting factors (relative sales volumes) were estimated using annual average, prime supplier, CG and RFG sales volumes (by grade) per day statistics for Texas.[22] This was performed for the summer season for CG regions using summer 2017 survey data. This was additionally performed for the summer and winter seasons, separately for DFW and HGB RFG areas, using the summer and winter 2017 RFG survey data. Since local winter data were unavailable for CG regions, TTI used appropriate MOVES 2017 winter CG defaults. For winter RFG, TTI used appropriate MOVES RVP defaults, since the winter RFG fuel property analyses exclude RVP. The gasoline formulations are shown in** Table 34 and Table 35. Since there was only one fuel formulation per region and season, each associated market share value in the fuel supply table was set to 1.0.

Development of Diesel Fuel Formulation Inputs – The TCEQ's 2017 summer fuel survey data were used to produce a single statewide average diesel sulfur level (6.37 ppm) for 2017 for all seasons and regions. The last three of the TCEQ's fuel surveys (2011, 2014, and 2017) provide similar observations for diesel sulfur content based on individual samples from the 92 locations across the state. Average sulfur content was within the range of 2 to 11 ppm and the average was approximately 6 ppm. Table 36 shows the diesel fuel formulation inputs. (The effects of TxLED on NO_x emissions from diesel vehicles were incorporated by emissions factor post-processing, discussed later.) The diesel formulation market share was set to 1.0 for each associated fuel region and month in the fuel supply table.

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[21] The fuel survey details are documented in *2017 Summer Fuel Field Study Final*, ERG, August 31, 2017.

[22] 2016 CG sales volumes were used for the summer 2017 average CG properties analysis, and 2016 RFG sales volumes were used for summer and winter 2017 average RFG properties analysis. The Energy Information Association (EIA) Texas Prime Supplier Sales Volumes of Petroleum Products reports are available at http://www.eia.gov/dnav/pet/pet_cons_prim_dcu_stx_a.htm.

Table 34. Summer 2017 Gasoline Fuel Formulation Input Estimates.

MOVES Fuel Formulation Field	Units	Region[1, 2, 3]						
		R1	R2	R3	R4		R5	R6
fuelFormulationID	-	17701	17702	17703	17714	17724	17705	17706
fuelSubtypeID[2]	-	12	12	12	12	12	12	12
RVP	psi	9.2	7.54	6.94	7	7.01	7.82	9.05
sulfurLevel	ppm	19.39	21.28	19.56	22.11	19.49	18.08	19.14
ETOHVolume	vol.%	9.74	9.66	9.6	9.67	9.67	9.69	9.47
MTBEVolume	vol.%	0	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0	0
aromaticContent	vol.%	24.63	25.35	26.67	14.74	15.62	28.93	17.02
olefinContent	vol.%	8.68	8.33	5.5	10.74	10.83	4.5	13.44
benzeneContent	vol.%	0.61	0.76	1.13	0.46	0.51	1.12	0.62
e200	vap.%	53.33	49.45	48.74	49.21	49.02	51.27	53.38
e300	vap.%	85.1	82.68	87.84	85.13	84.54	84.25	84.87
T50	deg. F	182.58	203.73	206.12	202.52	203.13	195.68	186.19
T90	deg. F	318.26	327.68	306.72	325.77	327.89	318.24	324.24

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver) and TxLED
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 17714 is DFW; ID 17724 is HGB) and TxLED
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10) and TxLED
R6	100000000	11	Same as R1, except a different distribution network (per EPA OTAQ).

[2] Fuel subtype ID 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

[3] Inputs were developed by TTI (for CG and RFG, respectively, using the TCEQ summer 2017 CG survey data and EPA summer 2017 RFG survey data for Dallas and Houston separately) as average fuel properties by fuel grade within each region, and overall averages as weightings of the individual fuel grade results, using EIA relative sales volumes for Texas.

Table 35. Winter 2017 Gasoline Fuel Formulation Input Estimates.

MOVES Fuel Formulation Field	Units	Region[1, 2, 3]			
		R1, R3	R2, R5, R6	R4	
fuelFormulationID	-	17101	17102	17114	17124
fuelSubtypeID[2]	-	12	12	12	12
RVP	psi	11.36	11.82	10.85	10.85
sulfurLevel	ppm	19.39	21.28	27.21	29.43
ETOHVolume	vol.%	10.00	10.00	10.13	9.84
MTBEVolume	vol.%	0	0	0	0
ETBEVolume	vol.%	0	0	0	0
TAMEVolume	vol.%	0	0	0	0
aromaticContent	vol.%	21.36	17.63	15.44	13.88
olefinContent	vol.%	6.66	9.33	10.07	10.39
benzeneContent	vol.%	0.63	0.61	0.47	0.45
e200	vap.%	53.72	55.11	57.97	58.66
e300	vap.%	87.38	84.04	84.72	84.60
T50	deg. F	192.22	189.39	157.72	151.50
T90	deg. F	309.50	324.68	325.03	314.00

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver) and TxLED
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 17114 is DFW; ID 17124 is HGB) and TxLED
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10) and TxLED
R6	100000000	11	Same as R1, except a different distribution network (per EPA OTAQ).

[2] Fuel subtype ID 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

[3] CG inputs (for R1, R2, R3, R5, and R6 counties) were developed by TTI using appropriate MOVES defaults due to lack of available CG winter survey data. TTI developed the RFG inputs using EPA 2017 winter RFG survey data for Dallas and Houston separately, as average fuel properties by fuel grade within each area, and overall averages as weightings of the individual fuel grade results, using EIA relative sales volumes for Texas (and using MOVES default RVP since RVP is not included with the EPA winter RFG survey data).

Table 36. 2017 Diesel Fuel Formulation Input Estimate.

MOVES Fuel Formulation Field[1,2]	Units	Statewide[3]
fuelFormulationID	-	30637
fuelSubtypeID[2]	-	20
RVP	psi	0
sulfurLevel[3]	ppm	6.37
ETOHVolume	vol.%	0
MTBEVolume	vol.%	0
ETBEVolume	vol.%	0
TAMEVolume	vol.%	0
aromaticContent	vol.%	0
olefinContent	vol.%	0
benzeneContent	vol.%	0
e200	vap.%	0
e300	vap.%	0
T50	deg. F	0
T90	deg. F	0

[1] The fuel region labels, associated MOVES fuel region IDs, and TxLED requirements are:

Label	fuelregionid	counties	Description
R1	300000000	132	No TxLED requirement
R2	178010000	95	TxLED required
R3	370010000	1	No TxLED requirement
R4	1370011000	12	TxLED required
R5	178000000	3	TxLED required
R6	100000000	11	No TxLED requirement

[2] Fuel subtype ID 20 is conventional diesel.

[3] Produced by TTI as statewide average for use in all seasons based on the TCEQ summer 2017 diesel survey data.

The actual fuelformation and fuelsupply input database tables used are included in the electronic data submittal as described in Appendix A.

Local I/M Inputs to MOVES

To model a local I/M program design, the program design must be defined using MOVES I/M coverage parameters by source type, entered in the MOVES imcoverage table. The TLM area counties, however, are not included in Texas I/M programs. An empty MOVES imcoverage table was included in each CDB.

Hotelling Activity Distribution Inputs to MOVES

To model emissions from long-haul truck hotelling activity with MOVES, a distribution of hotelling activity modes by model year may be input via the hotellingactivitydistribution table, otherwise the MOVES default is used. For previous inventory analyses, TTI used the MOVES default, currently comprised solely of the two emissions-producing hotelling activity modes, extended idling and diesel APU operation. For this analysis, TTI used the updated, more realistic hotelling activity distributions adopted in the TCEQ's 2017 truck idling study, comprised of four modes, extended idling and diesel APU use modes which produce emissions, and electric power use and power off modes which do not produce emissions. The updated hotellingactivitydistribution table inputs were previously shown in Table 27.

The MOVES input files (MRSs and CDBs) were provided as a part of the electronic data submittal (Appendix A) of this report.

Checks and Runs

After completing the input data preparation, the CDBs were checked to verify that all 21 tables were in the appropriate CDBs and the tables were populated with data as intended. The MOVES RunSpecs were executed in batches using the MOVES commandline tool. After completion, TTI verified that the MOVES runs were error free (i.e., checked all run log text files for errors and warnings).

The MOVES runs summaries are included as Appendix I.

Post-Processing Runs

Each MOVES output database was post-processed using the TTI's MOVES emissions rates post-processing utilities for on-road mobile emissions rates, RatesCalc and RatesAdj. Post-processing for each MOVES run was performed in two steps. RatesCalc first produced an interim "ratescalc" rate database, followed by a "ratesadj" database containing the final on-road rate tables produced by RatesAdj for input to the EmsCalc inventory calculation utility. The following post-processing procedures were performed on each MOVES output database.

- Interim Rate Databases: Using RatesCalc, the mass/SHP off-network evaporative process rates were calculated using data from the CDB, the MOVES default database, and the MOVES rateperprofile and ratepervehicle emissions rate output. The utility additionally copied the mass/mile, mass/start, and mass/hour rates along with the units into emissions rate tables. This utility does not perform any unit conversions, and excludes total energy and refueling processes. The utility created the look-up tables ttirateperdistance, ttirateperstart, ttirateperhour (for SHI and APU hours), and ttiratepershp in a "ratescalc" interim output database.

- Final Rate Databases: Using RatesAdj, TTI produced the final on-road mobile emissions rates for input to the EmsCalc emissions calculator. RatesAdj extracted emissions rates from the RatesCalc rate tables only for those pollutants needed in the emissions calculations. This step applied TxLED adjustments to the diesel vehicle NO_x emissions rates for all TLM area counties (see factors developed by TTI in Table 37). TTI produced these average diesel SUT NO_x adjustments using 4.8 percent and 6.2 percent reductions for 2002 and later, and 2001 and earlier model years, respectively.[23] The extracted and adjusted rate tables were placed in "outRatesAdj" databases (one each per run) for subsequent input to the on-road mobile source emissions calculator, EmsCalc.[24]

See the utility descriptions in Appendix B for more information.

Table 37. 2017 TxLED Adjustment Factors Summary.

Diesel Fuel Source Use Type	Reduction	Adjustment
Passenger Car	5.17%	0.9483
Passenger Truck	5.08%	0.9492
Light Commercial Truck	5.35%	0.9465
Intercity Bus	5.69%	0.9431
Transit Bus	5.66%	0.9434
School Bus	5.67%	0.9433
Refuse Truck	5.38%	0.9462
Single Unit Short-Haul Truck	4.89%	0.9511
Single Unit Long-Haul Truck	4.90%	0.9510
Motor Home	5.38%	0.9462
Combination Short-Haul Truck	5.19%	0.9481
Combination Long-Haul Truck	5.26%	0.9474

Source: TTI used the TxLED factor procedure from the TCEQ (available in "mvs14-statewide-txled-analysis-06-12-17-18.zip" available at: ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/txled/mvs14) in combination with statewide age distributions based on mid-year 2014 (latest available) TxDMV vehicle registrations.

The resulting hourly on-road rates were input to the EmsCalc utility to calculate the on-road mobile source inventories for each county. All emissions factor modeling inputs (MRS files and CDBs) and the final rates used in the inventories were provided electronically as described in Appendix A.

[23] Reductions as detailed in the EPA Office of Transportation and Air Quality Memorandum, RE: Texas Low Emission Diesel [LED] Fuel Benefits, September 27, 2001.

[24] The TxLED counties list may be found at: http://www.tceq.texas.gov/airquality/mobilesource/txled/txled-affected-counties. For full details on the TCEQ TxLED factor development procedure, see the zip files at: ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/txled/mvs14.

SUMMER WEEKDAY EMISSIONS CALCULATIONS

Using TTI's EmsCalc utility and the previously detailed inventory activity and emissions rate inputs, TTI calculated the hourly on-road mobile summer weekday inventory estimates for each county.

Under the TDM link-based inventory methodology, the on-road emissions calculation process falls into two vehicle activity categories: VMT-based emissions calculations and off-network emissions calculations. The VMT-based emissions calculations use the TDM link-based VMT and speeds to estimate emissions at the TDM roadway network link level (including added intrazonal links). The off-network emissions calculations use off-network activity (SHP, starts, SHI and APU hours) to estimate emissions at the county level.

EmsCalc produced three output files per run. These outputs consist of a listing file (summarizing information regarding the execution of the utility), a standard tab-delimited emissions inventory summary, and a tab-delimited 24-hour emissions inventory summary by SCCs and pollutant codes consistent with EPA's 2017 NEI.

Hourly Link-Based Emissions Calculations

The hourly emissions were calculated by county using EmsCalc and the following major inputs.

- Time period TxDOT district-level vehicle type VMT mix – by MOVES roadway type.
- Time period designations – the four VMT mix time periods to hour-of-day associations.
- Roadway-based activity for TDM-based counties – link (and intrazonal link)-specific, hourly, directional, operational VMT and speed estimates as developed by the TRANSVMT utility to include: A-node, B-node, county number, TDM road type (functional class) code, link length, congested (operational) speed, VMT, and TDM area type code.
- Roadway-based activity for HPMS virtual link-based counties – virtual link VMT and speeds estimates, which contain the link-specific, hourly, directional, operational VMT and speed estimates as developed by the VirtualLinkVMT utility to include: HPMS area type code, HPMS functional class code, county number, HPMS area type and functional-class combination code, HPMS center line miles, congested speed, and VMT.
- Road type designations for TDM-based counties – TDM road type and area type codes to MOVES road type codes (see Table 38 and Table 39).
- Road type designations for virtual link-based counties – virtual link road type and area type codes to MOVES road type codes (see Table 40).
- Off-network activity – county, hourly SHP, starts, SHI, and APU hours by vehicle type.
- Pollutant/process/units list – for emissions to be calculated and output in tab-delimited emissions summary files.[25]

[25] Note that TTI dropped MTBE from pollutants list for the EmsCalc inventory runs because the MOVES runs produced zero emissions rates for MTBE.

- Roadway-based emissions factors – MOVES-based, county level by pollutant, process, hour, average speed, MOVES road type, SUT, and fuel type.
- Off-network (parked vehicle) emissions factors – MOVES-based, county level by pollutant, process, hour, SUT, and fuel type.
- SCCs – mapping of MOVES source type, fuel type, road type, process codes to SCCs.
- MOVES pollutant codes to NEI pollutant codes – for SCC output.

Table 38. Longview TDM (Gregg County) Road Type/Area Type to MOVES Road Type Designations.

<table>
<tr><th>TDM Road Type
(Code - Name)[1]</th><th>TDM Area Type
(Code - Name)[1]</th><th>MOVES Road Type
(Code - Name)[1, 2]</th></tr>
<tr><td>1 - Radl IH Fwy ML</td><td>4 - Rural</td><td>2 - Rural Restricted Access</td></tr>
<tr><td>0 - Centroid Conn.
11 - Prin Art Div
12 - Prin Art CLT Lane
13 - Prin Art Undiv
15 - Min Art CLT Lane
16 - Min Art Undiv
17 - Coll Div
18 - Coll CLT Lane
19 - Coll Undiv
20 - Frontage Road
21 - Ramp (FR to ML)</td><td>4 - Rural</td><td>3 - Rural Unrestricted Access</td></tr>
<tr><td>1 - Radl IH Fwy ML</td><td>1 - CBD
2 - Urban
3 - Suburban</td><td>4 - Urban Restricted Access</td></tr>
<tr><td>0 - Centroid Conn.
11 - Prin Art Div
12 - Prin Art CLT Lane
13 - Prin Art Undiv
15 - Min Art CLT Lane
16 - Min Art Undiv
17 - Coll Div
18 - Coll CLT Lane
19 - Coll Undiv
20 - Frontage Road
21 - Ramp (FR to ML)</td><td>1 - CBD
2 - Urban
3 - Suburban</td><td rowspan="2">5 - Urban Unrestricted Access</td></tr>
<tr><td>40 – Intrazonal</td><td>Local (Intrazonal)</td></tr>
</table>

[1] The TDM road type and area type code combinations are additionally correlated to VMT mix road type codes and emissions rate road type codes, which, for this analysis, are identical to the MOVES road type codes.

[2] The four period, time-of-day VMT mix to hour-of-day designations are: AM peak – three hours of 6 a.m. to 9 a.m.; mid-day – seven hours of 9 a.m. to 4 p.m.; PM peak – three hours of 4 p.m. to 7 p.m.; and overnight – 11 hours of 7 p.m. to 6 a.m.

Table 39. Tyler (Smith County) TDM Road Type/Area Type to MOVES Road Type Designations.

TDM Road Type (Code - Name)[1]	TDM Area Type (Code - Name)[1]	MOVES Road Type (Code - Name)[1, 2]
1 - Radl IH Fwy ML 10 - Circ. Expressways (Loops)	4 - Rural	2 - Rural Restricted Access
0 - Centroid Conn. 11 - Prin Art Div 12 - Prin Art CLT Lane 13 - Prin Art Undiv 14 - Min Art Div 15 - Min Art CLT Lane 16 - Min Art Undiv 19 - Coll Undiv 21 - Ramp (FR to ML)	4 - Rural	3 - Rural Unrestricted Access
1 - Radl IH Fwy ML 10 - Circ. Expressways (Loops)	1 - CBD 2 - Urban 3 - Suburban	4 - Urban Restricted Access
0 - Centroid Conn. 11 - Prin Art Div 12 - Prin Art CLT Lane 13 - Prin Art Undiv 14 - Min Art Div 15 - Min Art CLT Lane 16 - Min Art Undiv 19 - Coll Undiv 21 - Ramp (FR to ML)	1 - CBD 2 - Urban 3 - Suburban	5 - Urban Unrestricted Access
40 – Intrazonal	Local (Intrazonal)	

[1] The TDM road type and area type code combinations are additionally correlated to VMT mix road type codes and emissions rate road type codes, which, for this analysis, are identical to the MOVES road type codes.

[2] The four period, time-of-day VMT mix to hour-of-day designations are: AM peak – three hours of 6 a.m. to 9 a.m.; mid-day – seven hours of 9 a.m. to 4 p.m.; PM peak – three hours of 4 p.m. to 7 p.m.; and overnight – 11 hours of 7 p.m. to 6 a.m.

Table 40. Virtual Link Road Type/Area Type to MOVES Road Type Designations.

Virtual Link Road Type (Code – Name) [1]	Virtual Link Area Type (Code – Name) [1]	MOVES Road Type (Code - Name) [1, 2]
0 - Rur IH Fwy	1 - Rural	2 - Rural Restricted Access
2 - Rur Oth Prin Art 3 - Rur Minor Art 4 - Rur Major Coll 5 - Rur Minor Coll 6 - Rur Local	1 - Rural	3 - Rural Unrestricted Access
7 - Small Urb IH Fwy 8 - Small Urb Fwy	2 - Small Urban	4 - Urban Restricted Access
14 - Urb IH Fwy 15 - Urb Fwy	3 - Urban	
10 - Small Urb Min Art 11 - Small Urb Maj Coll 12 - Small Urb Min Coll 13 - Small Urb Local 9 - Small Urb Oth Pr Art	2 - Small Urban	5 - Urban Unrestricted Access
16 - Urb Oth Prin Art 17 - Urb Min Art 18 - Urb Maj Coll 20 - Urb Local	3 - Urban	

[1] The virtual link road type and area type code combinations are additionally correlated to VMT mix road type codes and emissions rate road type codes, which, for this analysis, are identical to the MOVES road type codes.

[2] The four period, time-of-day VMT mix to hour-of-day designations are: AM peak – three hours of 6 a.m. to 9 a.m.; mid-day – seven hours of 9 a.m. to 4 p.m.; PM peak – three hours of 4 p.m. to 7 p.m.; and overnight – 11 hours of 7 p.m. to 6 a.m.

The VMT-based emissions were calculated for each hour using the time-period, TxDOT district-level vehicle type VMT mix, the link VMT and speeds estimates, the MOVES-based "on-network" emissions factors, and the link road type/area type-to-MOVES road type designations. For each link, the link was assigned a MOVES road type based on the link's road type and area type (see Table 38, Table 39, and Table 40). The link VMT was distributed to each vehicle type using the VMT mix from the appropriate time period based on the link's designated MOVES road type. The AM peak, Mid-Day, PM peak, and Overnight VMT mixes were applied by hour according to the local area time periods designation file which assigns each hour of the day to one of the four periods.

The emissions factors by hour for each vehicle type were selected based on the designated hour of the link file, and the link's designated MOVES road type and the link speed. For link speeds falling between MOVES speed bin average speeds, emissions factors were interpolated from bounding speeds. For link speeds falling outside of the MOVES speed range (less than 2.5 mph and greater than 75 mph), the emissions factors for the associated bounding speeds were used. The mass/mi rates were multiplied by the link vehicle type VMT producing the link-level emissions estimates. This was performed for each hour of the day.

The off-network emissions were calculated at the county-level by multiplying the hourly, vehicle type off-network emissions factors by the appropriate county-level hourly, vehicle type off-network activity, which was determined by the pollutant emissions process of the associated emissions rate table.

The 24-hour SCC tab-delimited output was produced by aggregating the standard tab-delimited 24-hour output as needed for input to TTI's MOVESsccXMLformat utility, which produced the inventory summaries coded, aggregated and formatted for uploading to EPA's EIS and to the TCEQ's TexAER. These aggregations were performed:

- From 84 pollutants to 62 pollutants:
  - 41 pollutants aggregated to 19;
    - Three mercury compounds to one;
    - Three PM_{10} pollutants (exhaust, brakewear, tirewear) to one;
    - Three $PM_{2.5}$ pollutants (exhaust, brakewear, tirewear) to one; and
    - 32 PAH pollutants (16 each in gaseous and particulate phases) to 16;
  - 43 pollutants to 43 (not aggregated).
- From the standard disaggregate level of activity (with on-network roadway-based and off-network types) and emissions by process, road type, source type, and fuel type to:
  - Total emissions (all on- and off-network processes except refueling);
  - Total VMT for all roads by source type and fuel type (only VMT activity is reported).

Hourly Link-Based Emissions Output

The EmsCalc hourly link-based emissions output datasets consisted of three output files per run. These output files are:

- A listing file that summarizes the utility execution information, including the inputs and outputs, providing summaries of the VMT mix, the off-network activity, the emissions factor dimensions (i.e., hour, MOVES road type, MOVES speed bin, SUT, fuel type, pollutant, process), and an hourly totals summary of VMT, VHT, speed, off-network activity, and emissions in pounds;
- A tab-delimited summary output file consisting of one header section followed by hourly and 24-hour totals data blocks of on-road activity and emissions (in units of pounds). Summaries are by road type and vehicle type of VMT, VHT, speed (VMT/VHT), pollutant, and pollutant process (with the "off-network" category listed as the last road type preceding the TOTALS row in each data block), and with starts, SHP, SHI, and APU activity rows last in the activity data block for each time period; and
- A tab-delimited summary SCC output file that contains the 24-hour totals of VMT and emissions (in units of pounds) using inventory data aggregations, SCCs, and pollutant codes consistent with the EPA's 2017 NEI.

There were 84 pollutants in the standard output (VOC, CO, NO_x, NH_3, SO_2, CO_2, PM_{10} Total Exhaust, PM_{10} Brakewear, PM_{10} Tirewear, $PM_{2.5}$ Total Exhaust, $PM_{2.5}$ Brakewear, $PM_{2.5}$ Tirewear, OC, EC, SO_4, and the HAPs) and after the previously mentioned aggregations, 62 pollutants in the SCC output.

See Appendix B for further details on the EmsCalc utility.

XML-Formatted 24-Hour Summaries for TexAER

TTI post-processed the EmsCalc 24-hour summer weekday SCC-labeled inventory output, using the TTI's MOVESsccXMLformat utility, into the NEI EIS CERS XML format for inclusion in the TCEQ's TexAER database and EPA's EIS.

The tab-delimited SCC-based inventory files output by EmsCalc were produced for direct input to the XML format utility using inventory data aggregation and coding (SCCs and pollutant codes) consistent with EPA's 2017 (and 2014) NEI, as required for compatibility with TexAER (and EIS). The current NEI SCC codes are aggregations of the more detailed MOVES SCC codes, providing the total emissions for each valid NEI pollutant by source type and fuel type (e.g., by pollutant, for on-road, the total emissions from all roadway-based and off-network processes, excluding refueling).

The on-road 24-hour day emissions inventory XML summaries include VOC, CO, NO_x, SO_2, NH_3, CO_2, $PM_{2.5}$ and PM_{10} (PMs are the aggregation of exhaust, tirewear, and brakewear). Each run produced an LST file, the XML file, and one tab-delimited SCC-labeled inventory summary per county. (Inventory data for all 254 Texas counties were converted to XML format. Further details may be found in Appendix A.)

ANNUAL ACTIVITY AND EMISSIONS

Two of the main components of the summer weekday emissions are activity and emissions rates. To incorporate seasonal changes in both the activity and emissions rates, activity and emissions rate annualization factors were used in the annualization methodology.

The activity annualization factors consist of a VMT annualization factor, a hotelling hours annualization factor (used for SHI and APU hours), starts annualization factors by SUT, and SHP annualization factors by SUT. These factors were used to convert the summer weekday activity component of the emissions and to annualize the summer weekday activity.

The emissions rate annualization factors by pollutant, process, SUT, fuel type, and aggregate road type (restricted access, unrestricted access, off-network) were calculated from MOVES inventory mode runs. These factors were needed to accommodate changes in emissions rates between the summer season weekday and the remainder of the year due to the variation in various seasonal parameters.

Generally, the summer weekday activity was annualized by applying the appropriate activity annualization factor to the summer weekday activity and the summer weekday emissions were annualized by applying the appropriate activity annualization factor and emissions rate annualization factor to the summer weekday emissions. In some cases (e.g., heavy duty summer start emissions), emissions rate annualization factors did not exist (mainly due to emissions existing in some seasons but not in summer weekday). In these cases, the annual emissions were calculated by multiplying the annual emissions rate (from the emissions rate annualization factor procedures) by the annual activity.

Annual Activity and Annualization Factors

To estimate the annual emissions and build the annual MOVES inventory mode databases in a consistent manner (i.e., so that annualized summer weekday activity will be closely replicated by a MOVES inventory mode run), the summer weekday activity was converted to annual activity based on the MOVES calculation procedures to a format suitable for use with the MOVES inventory mode. This annual activity was then used to construct the activity annualization factors that were applied during the annual emissions estimation process. Activity annualization procedures follow for VMT, hotelling hours, starts, and SHP.

Annual VMT and Annualization Factors

The MOVES calculation procedure for VMT allocates annual VMT by the MOVES defined HPMS vehicle types to summer weekday VMT by HPMS vehicle type using month VMT fractions, day VMT fractions, number of days in the month, and the number of days in the period for the day VMT fraction. The formula for the MOVES VMT allocation procedure is:

$$SWkdVMT_{HPMSVtype} = AVMT_{HPMSVtype} * monthFract_{Month} * dayFract_{Month,DayType} / (noOfDays/7) / noOfRealDays$$

Where:

$SWkdVMT_{HPMSVtype}$ = summer weekday VMT by HPMS vehicle type;
$AVMT_{HPMSVtype}$ = annual VMT by HPMS vehicle type;

$monthFract_{Month}$	=	month VMT fraction for the desired month;
$dayFract_{Month,DayType}$	=	day VMT fraction for the desired day type (weekday or weekend day by month);
noOfDays	=	number of days in the desired month; and
noOfRealDays	=	number of days in the desired day type (5 for weekday, 2 for weekend day).

Since the objective was to estimate annual VMT from the summer weekday VMT, the formula from the MOVES VMT allocation procedure can be transformed to calculate the annual VMT from the summer weekday VMT by reversing the calculations. The formula for calculating the annual VMT by HPMS vehicle type from the summer weekday VMT is:

$$AVMT_{HPMSVtype} = SWkdVMT_{HPMSVtype} * noOfRealDays *(noOfDays/7)/ dayFract_{Month,DayType} / monthFract_{Month}$$

The number of days in the day type (noOfRealDays) and number of days in the month (noOfDays) were determined by the emissions inventory being annualized. Since the inventories were for summer (July) weekday, the number of days in the day type was set to 5 and the number of days in the month was set to 31. Day VMT fractions and month VMT fractions were developed by TxDOT district using aggregated ATR data (years 2007 - 2016). See Appendix J for the day VMT fractions and the month VMT fractions. For each county, this calculation procedure was applied to the summer weekday VMT for each HPMS vehicle type (output from the MOVESactivityInputBuild utility, see Appendix A) and saved for use in building the annual MOVES inventory mode databases.

The county-level VMT annualization factor was then calculated by dividing the county total annual VMT by the county total summer weekday VMT. Appendix K shows the summer weekday VMT, annual VMT and VMT annualization factors for each county.

Annual Hotelling Hours and Annualization Factors

The annual hotelling hours were calculated using similar logic and input parameters as the VMT annualization procedure. Since the hotelling hours input to MOVES is required by age, the hourly summer weekday hotelling hours (from the emissions inventory development process) was distributed to each age category using travel fractions. The hourly summer weekday hotelling hours by age was then converted to hourly annual hotelling hours by age. The hourly annual hotelling hours by age was then converted to the proper format for use with the MOVES inventory mode databases (hotelling hours by month, day type, hour, and age). The county total annual hotelling hours were then used to calculate the hotelling annualization factor, which was used during the emissions annualization process to annualize the SHI and APU hours activity.

Travel fractions were used to distribute the hourly summer weekday hotelling hours to each of the MOVES age categories. These travel fractions were calculated using the county-specific age distribution for SUT 62 (additionally used in the MOVES emissions rate runs) and the county-specific relative mileage accumulation rates (adjusted to reflect the VMT mix in the summer weekday emissions inventory) for SUT 62. The travel fractions by age were calculated by multiplying the age distribution by the relative mileage accumulation rates for each age and dividing by the sum of the product for all the age categories. The travel fractions were calculated using the following formula:

$$TF_{Age} = (STAD_{Age} * RelMAR_{Age}) / \sum(STAD_{Age} * RelMAR_{Age})$$

Where:

TF_{Age}	=	the travel fractions by age category;
$STAD_{Age}$	=	source type age distribution for SUT 62 by age;
$RelMAR_{Age}$	=	relative mileage accumulation rates (MARs) by age (adjusted to reflect the VMT mix in the summer weekday emissions inventory) for SUT 62 by age; and
$\sum$ ( )	=	sum of ($STAD_{Age}$ * $RelMAR_{Age}$) across all age categories.

The travel fractions were then used to calculate the hourly summer weekday hotelling hours by age from the hourly summer weekday hotelling hours used in the emissions inventory development process. The hourly summer weekday hotelling hours by age were calculated using the following formula:

$$SWkdHH_{Hour,Age} = SWkdHH_{Hour} * TF_{Age}$$

Where:

$SWkdHH_{Hour,Age}$	=	hourly summer weekday hotelling hours by age;
$SWkdHH_{Hour}$	=	hourly summer weekday hotelling hours from the emissions inventory development process; and
TF_{Age}	=	the travel fractions by age category.

The hourly annual hotelling hours by age were then calculated using a similar procedure to the annual VMT using the day and month fractions (see Appendix J):

$$AHH_{Hour,Age} = SWkdHH_{Hour,Age} * noOfRealDays * (noOfDays/7) / dayFract_{Month,DayType} / monthFract_{Month}$$

Where:

$AHH_{Hour,Age}$	=	hourly annual hotelling hours by age;
$SWkdHH_{Hour,Age}$	=	hourly summer weekday hotelling hours by age;
noOfRealDays	=	number of days in the desired day type – 5 for summer weekday;
noOfDays	=	number of days in the desired month – 31 for summer (July) weekday;
$dayFract_{Month,DayType}$	=	day VMT fraction for summer (July) weekday (see Appendix J); and
$monthFract_{Month}$	=	month VMT fraction for summer (July, See Appendix J).

Since the annual MOVES inventory mode databases additionally require the hotelling hours input for each month and day type (weekday and weekend day) portions of the week, the annual hotelling hours by age were calculated for each month and day type period (total of 24 sets of hotelling hours) using the following formula:

$$HH_{Month,DayPeriod,Hour,Age} = AHH_{Hour,Age} * monthFract_{Month} * dayFract_{Month,DayType} / (noOfDays/7)$$

Where:

$HH_{Month,DayPeriod,Hour,Age}$	=	hotelling hours by month, day type period, hour, and age;
$AHH_{Hour,Age}$	=	hourly annual hotelling hours by age;
$monthFract_{Month}$	=	month VMT fraction (See Appendix J);
$dayFract_{Month,DayType}$	=	day VMT fraction (see Appendix J); and
noOfDays	=	number of days in the month.

The hotelling annualization factor was then calculated by dividing the county total hotelling hours by the county total summer weekday hotelling hours. This hotelling annualization factor was used for annualizing the SHI and APU hours activity in the emissions annualization process. Appendix K shows the annual hotelling hours, summer weekday hotelling hours, and annualization factors for each county.

Annual Starts and Annualization Factors

The annual starts inputs to MOVES require starts by month, portion of the week (weekday portion and weekend day portion), hour, SUT, and age. These annual starts were calculated based on the summer weekday starts from the emissions inventory development process. The annual starts were additionally used, along with the summer weekday starts, to calculate county-level starts annualization factors by SUT.

In the emissions inventory development process, summer weekday starts were calculated by hour, SUT, and fuel type using the MOVES default weekday starts-per-vehicle. Since the MOVES default starts-per-vehicle do not vary by fuel type, all calculations were performed by SUT. To calculate the annual starts from the summer weekday starts, the starts for a summer weekend day must be calculated. This calculation was performed using weekend day equivalency factors, which were calculated by dividing the hourly MOVES default weekend day starts-per-vehicle by the hourly MOVES default weekday starts-per-vehicle. These equivalency factors were calculated using the formula:

$$WEDSEF_{Hour,SUT} = WEDSPV_{Hour,SUT} / WKDSPV_{Hour,SUT}$$

Where:

$WEDSEF_{Hour,SUT}$	=	weekend day starts equivalency factors by hour and SUT;
$WEDSPV_{Hour,SUT}$	=	MOVES default weekend day starts-per-vehicle by hour and SUT; and
$WKDSPV_{Hour,SUT}$	=	MOVES default weekday starts-per-vehicle by hour and SUT.

These equivalency factors were then used to convert the summer weekday starts from the emissions inventory development process to summer weekend day starts. The hourly summer weekday starts (by SUT and fuel type) were aggregated by SUT to produce hourly summer weekday starts by SUT and the equivalency factors were applied to calculate the summer weekend day starts by SUT. The summer weekend day starts were calculated using the following formula:

$$WEDS_{Hour,SUT} = WKDS_{Hour,SUT} * WEDSEF_{Hour,SUT}$$

Where:

$WEDS_{Hour,SUT}$ = summer weekend day starts by hour and SUT;
$WKDS_{Hour,SUT}$ = summer weekday starts by hour and SUT; and
$WEDSEF_{Hour,SUT}$ = weekend day starts equivalency factors by hour and SUT.

MOVES requires starts by portion of the week (weekday portion and weekend portion), which means the summer weekday and summer weekend day starts by hour and SUT must be converted to portion of the week. This conversion is performed using the number of days in the portion of week (5 for weekday, 2 for weekend day). The following formula was used to convert both the summer weekday and summer weekend day starts to portions of the week:

$$Starts_{WeekPortion,Hour,SUT} = DailyStarts_{Day\ Type,Hour,SUT} * noOfRealDays$$

Where:

$Starts_{Week,Portion,Hour,SUT}$ = starts by portion of the week, hour, and SUT;
$DailyStarts_{Day\ Type,\ hour,SUT}$ = daily starts by day type, hour, and SUT (summer weekday and summer weekend day); and
noOfRealDays = number of days in the portion of the week (5 for weekday, 2 for weekend day).

Since the MOVES default starts-per-vehicle and the vehicle population used to calculate starts do not vary by month, the starts for each month were set equal to the summer weekday portion of the week and summer weekend day portion of the week starts by hour and SUT, which completes the dataset required for the MOVES inventory mode database. To calculate the starts annualization factors by SUT, the annual starts by SUT must be calculated. Since the monthly starts are by portion of the week, weekly starts by SUT were calculated for each month by summing the portion of the week starts, and the weekly starts by SUT were converted to monthly starts by SUT. These monthly starts were then summed to obtain the annual starts by SUT using the following formula:

$$AStarts_{SUT} = \sum[WStarts_{Month,SUT} *(noOfDays/7)]$$

Where:

$AStarts_{SUT}$ = annual starts by SUT;
$WStarts_{Month,SUT}$ = weekly starts by month and SUT;
noOfDays = number of days in the month; and
$\sum[\ ]$ = sum of the monthly starts.

The second component of the starts annualization factors by SUT is the summer weekday starts by SUT. The summer weekday starts by hour and SUT used in the emissions inventory development process were aggregated across hours and fuel types for each SUT to produce summer weekday starts by SUT. The annual starts by SUT were then divided by the summer weekday starts by SUT to produce the starts annualization factors by SUT. Appendix K shows the starts annualization factors by SUT for each county.

Annual SHP and Annualization Factors

The annual SHP required to calculate SHP annualization factors was calculated using a process very similar to MOVES. This annual SHP was then used, along with the summer weekday SHP, to calculate SHP annualization factors. All calculations were performed for each county.

The first step in calculating annual SHP was to calculate the SUT vehicle population by age using the source type age distribution. Following is the formula used to calculate the SUT vehicle population by age:

$$VehPop_{SUT,Age} = VehPop_{SUT} * AgeDist_{SUT,Age}$$

Where:

$VehPop_{SUT,Age}$	=	vehicle population by SUT and age;
$VehPop_{SUT}$	=	vehicle population by SUT; and
$AgeDist_{SUT,Age}$	=	source type age distribution by SUT and age.

The next step in calculating the annual SHP was to calculate the vehicle population within each MOVES designated HPMS vehicle class. Each SUT in the vehicle population by SUT was assigned an HPMS vehicle class and the vehicle population was summed for each HPMS vehicle type.

The next step in calculating the annual SHP was to calculate the vehicle population fractions within each HPMS vehicle class. For each SUT, the vehicle population by SUT and age was assigned an HPMS vehicle class and divided by the appropriate HPMS vehicle class. Following is the formula for calculating the vehicle population fractions within each HPMS vehicle class:

$$HVehFract_{SUT,Age} = VehPop_{SUT,Age} / VehPop_{HPMSvtype}$$

Where:

$HVehFract_{SUT,Age}$	=	vehicle population fractions within each HPMS vehicle class by SUT and age;
$VehPop_{SUT,Age}$	=	vehicle population by SUT and age; and
$VehPop_{HPMSvtype}$	=	vehicle population by HMPS vehicle type.

The next step in calculating the annual SHP was to calculate the travel fractions by SUT and age. These travel fractions, which represent the amount of travel by SUT and age within each HPMS vehicle type, were calculated by multiplying the vehicle population fractions within each HPMS vehicle class (SUT and age) by the relative MARs (SUT and age) and divided by the sum of the product by HPMS vehicle type. The relative MARs were adjusted to reflect the 24-hour VMT mix contained in the summer weekday activity and emissions. Following is the formula for calculating the travel fractions by SUT and age:

$$TF_{SUT,Age} = HVehFract_{SUT,Age} * relMAR_{SUT,Age} / \sum(HVehFract_{SUT,Age} * relMAR_{SUT,Age})_{HPMSvtype}$$

Where:

$TF_{SUT,Age}$	=	travel fraction by SUT and age;
$HVehFract_{SUT,Age}$	=	vehicle population fractions within each HPMS vehicle class by SUT and age;
$relMAR_{SUT,Age}$	=	relative MARs by SUT and age; and
$\sum ( )$	=	sum of ($HVehFract_{SUT,Age}$ * $relMAR_{SUT,Age}$) across HPMS vehicle type.

The annual VMT by road type, SUT, and age was then calculated by multiplying the annual VMT by HPMS vehicle type (from the VMT annualization process described previously), the road type distribution by SUT and road type, and the travel fractions. Following is the formula for calculating the annual VMT by road type, SUT, and age:

$$AVMT_{RoadType,SUT,Age} = AVMT_{HPMSVtype} * RDIST_{SUT,RoadType} * TF_{SUT,Age}$$

Where:

$AVMT_{RoadType,SUT,Age}$	=	annual VMT by road type, SUT, and age;
$AVMT_{HPMSVtype}$	=	annual VMT by HPMS vehicle type;
$RDIST_{SUT,RoadType}$	=	road type distribution by SUT and road type; and
$TF_{SUT,Age}$	=	travel fraction by SUT and age.

The annual VMT by road type, SUT, and age was then allocated to each month, day period (weekday and weekend day), and hour by multiplying by the month VMT fraction, the day VMT fraction, and hour VMT fraction, and dividing by the number of weeks in the month (number of days in the month divided by seven). Following is the formula for calculating the VMT by month, day period, hour, road type, SUT, and age:

$$VMT_{Month,DayPeriod,Hour,Roadtype,SUT,Age} = AVMT_{RoadType,SUT,Age} * monthFract_{Month} * dayFract_{Month,DayType} * hourFract_{DayType,Hour} / (noOfDays_{Month}/7)$$

Where:,

$VMT_{Month,DayPeriod,Hour,Roadtype,SUT,Age}$	=	VMT by month, day period, hour, road type, SUT, and age;
$AVMT_{RoadType,SUT,Age}$	=	annual VMT by road type, SUT, and age;
$monthFract_{Month}$	=	month VMT fraction by month;
$dayFract_{Month,DayType}$	=	day VMT fraction by month and day type; and
$hourFract_{DayType,Hour}$	=	hour VMT fraction by day type and hour; and
noOfDays	=	number of days in the month.

The average speed by day type, hour, SUT, and road type was then calculated by multiplying the average speed distribution (day type, hour, SUT, road type, and average speed bin) by the average speed bin speeds and summing across the speed bins. Following is the formula used to calculate the average speed by day type, hour, SUT, and road type:

$$ASPD_{DayType,Hour,SUT,RoadType} = \sum(SPDD_{DayType,Hour,SUT,RoadType,SpeedBin} * SPDB_{SpeedBin})$$

Where:

$ASPD_{DayType,Hour,SUT,RoadType}$	=	average speed by day type, hour, SUT, and road type;
$SPDD_{DayType,Hour,SUT,RoadType,SpeedBin}$	=	average speed distribution by day type, hour, SUT, road type, and average speed bin;
$SPDB_{SpeedBin}$	=	speed bin speeds by speed bin; and
$\sum(\,)$	=	sum across speed bins.

The SHO by month, day period, hour, road type, SUT, and age was then calculated by dividing the VMT (month, day period, hour, road type, SUT, and age) by the average speed (day type, hour, SUT, and road type). Following is the formula used for calculating the SHO by month, day period, hour, road type, SUT, and age:

$$SHO_{Month,DayPeriod,Hour,Roadtype,SUT,Age} = VMT_{Month,DayPeriod,Hour,Roadtype,SUT,Age} / ASPD_{DayType,Hour,SUT,RoadType}$$

Where:

$SHO_{Month,DayPeriod,Hour,Roadtype,SUT,Age}$	=	SHO by month, day period, hour, road type, SUT, and age;
$VMT_{Month,DayPeriod,Hour,Roadtype,SUT,Age}$	=	VMT by month, day period, hour, road type, SUT, and age; and
$ASPD_{DayType,Hour,SUT,RoadType}$	=	average speed by day type, hour, SUT, and road type.

The SHO by month, day period, hour, road type, SUT, and age was then summed across the road types to produce the SHO by month, day period, hour, SUT, and age. This SHO was then used to calculate the SHP by month, day period, hour, SUT, and age. The vehicle population (SUT and age) was multiplied by the number of days in the day period (5 for weekday period and 2 for weekend day period) to calculate the day period vehicle population. The SHO (month, day period, SUT, and age) was then subtracted from the day period vehicle population to calculate the SHP by month, day period, hour, SUT, and age. Following is the formula used to calculate the SHP by month, day period, hour, SUT, and age:

$$SHP_{Month,DayPeriod,Hour,SUT,Age} = (VehPop_{SUT,Age} * noOfRealDays) - SHO_{Month,DayPeriod,Hour,SUT,Age}$$

Where:

$SHP_{Month,DayPeriod,Hour,SUT,Age}$	=	SHP by month, day period, hour, SUT, and age;
$VehPop_{SUT,Age}$	=	vehicle population by SUT and age;
noOfRealDays	=	number of days in the day period (5 for weekday, 2 for weekend day); and
$SHO_{Month,DayPeriod,Hour,SUT,Age}$	=	SHO by month, day period, hour, SUT, and age.

The SHP by SUT for the month and day type to be annualized (July weekday in this case) was then calculated using the SHP by month, day period, hour, SUT, and age. For those SHP values greater than zero (negative SHP values are set to zero since those values indicate that SHP does not exist), the SHP (month, day period, hour, SUT, and age) was divided by the number of days in the day period (5 for weekday in this case) and summed across hour and age. Following is the formula for calculating the daily SHP by SUT:

$$DSHP_{SUT} = \sum MAX[\ SHP_{Month,DayPeriod,Hour,SUT,Age}\ /\ noOfRealDays,\ 0]$$

Where:

$DSHP_{SUT}$	=	daily SHP by SUT for the month and day type annualized (July weekday in this case);
$SHP_{Month,DayPeriod,Hour,SUT,Age}$	=	SHP by month, day period, hour, SUT, and age for the month and day type annualized (July weekday in this case);
noOfRealDays	=	number of days in the day period annualized (5 for weekday in this case); and
∑MAX[ ]	=	sum of the maximum value between ($SHP_{Month,DayPeriod,Hour,SUT,Age}$/noOfRealDays) and 0 across hour and age.

The annual SHP by SUT was calculated using a similar procedure as the daily SHP except that the calculations were performed for each month and day period. Following is the formula for calculating the annual SHP by SUT:

$$ASHP_{SUT} = \sum MAX[\ SHP_{Month,DayPeriod,Hour,SUT,Age}\ /\ noOfRealDays,\ 0]$$

Where:

$ASHP_{SUT}$	=	annual SHP by SUT;
$SHP_{Month,DayPeriod,Hour,SUT,Age}$	=	SHP by month, day period, hour, and SUT;
noOfRealDays	=	number of days in the day period (5 for weekday, 2 for weekend day); and
∑ MAX[ ]	=	sum of the maximum value between ($SHP_{Month,DayPeriod,Hour,SUT,Age}$/noOfRealDays) and 0 across month, day period, hour, and age.

The annual SHP by SUT were then divided by the daily (July weekday) SHP by SUT to produce the SHP annualization factors by SUT. Appendix K shows the SHP annualization factors by SUT for each county.

Emissions Rate Annualization Factors

Emissions rate annualization factors by pollutant, process, SUT, fuel type, and aggregate road type (restricted access, unrestricted access, off-network) were additionally used to create annual emissions from the summer weekday emissions. These factors were based on two MOVES inventory mode runs: one to produce annual activity and emissions (e.g., summer and winter seasonal inputs); and one to produce summer weekday emissions and activity (using similar inputs to the summer weekday MOVES emissions rate runs used to develop the summer weekday emissions inventories). Annual emissions rates, summer weekday emissions rates and annualization factors (annual rate divided by summer weekday rate) by pollutant, process, SUT, fuel type, and aggregate road type were calculated using the output from these two MOVES runs.

MOVES Inventory Mode Runs

For the development of the emissions rate annualization factors, two inventory mode runs were performed, one for a summer weekday, and one with seasonal variation for annual.

In the section entitled "Estimation of Summer Weekday Emissions Factors," Table 30 and Table 31 summarize the RunSpec settings and CDB inputs for the summer weekday emissions rate mode runs for the rates development. The inventory mode runs for rate annualization factor development are very similar to the rates mode runs; their differences in RunSpecs and CDBs are highlighted here.

RunSpecs: For the inventory mode runs, particular Scale, Time Spans, Geographic Bounds, and Output Emissions Detail settings are different. For inventory mode, "Calculation Type" was set to "Inventory" in the Scale panel; "Region" in the Geographic Bounds panel was changed from "Zone and Link" to "County;" and the appropriate CDB name was set. In the Time Spans panel, for summer weekday, there was no difference between inventory mode and rates mode, but for the generalized annual inventory mode run, for "Days," both "Weekdays" and "Weekend" were selected, and for "Months," both "January" and "July" were selected. Under Output Emissions Detail for inventory mode, "Time" was set to "24 Hour Day" for the summer weekday run, and to "Month" for the generalized annual run.

CDBs: For the inventory mode, only one CDB was needed for both the summer weekday run and the generalized annual run. Both summer and winter season meteorological inputs (see Appendix H) and fuels inputs (see Table 34, Table 35, and Table 36) were included in each CDB (as was the case for the rates mode CDBs). Additionally, month VMT fractions were changed to account for local semi-annual seasonal activity at the associated district level. July and January monthVMTfraction values, respectively, were set to one-sixth of the generalized, semi-annual summer [April through September] and one-sixth of the winter [remaining six months] ATR counts. For developing these summer and winter month VMT fractions for motorcycles, the MOVES defaults were used to account for substantially higher seasonal variation for this SUT, not individually distinguishable in the local aggregate fleetwide fractions.

TTI built the MRSs and CDBs for each county and checked that they were prepared as intended. The MOVES runs were performed, checked for errors, and applied in the calculation of the emissions rate annualization factors for each county. The MRSs, CDBs (and scripts used to build them), and MOVES output were provided as a part of the electronic data submittal (see Appendix A).

Emissions Rate Annualization Factor Calculations

The first component of the emissions rate annualization factors is the annual emissions rates. The emissions output from the annual MOVES inventory mode run was aggregated by pollutant, process, SUT, fuel type, and aggregate road type (restricted access, unrestricted access, off-network). The activity output was additionally aggregated by SUT, fuel type, aggregate road type, and activity type (i.e., VMT, starts, SHI, APU hours, and SHP). The annual emissions rates were then calculated by dividing the aggregated emissions output by the appropriate aggregated activity to produce annual emissions rates by pollutant, process, SUT, fuel type, and aggregate road type. Using the same procedure, summer weekday emissions rates were calculated using the output from the summer weekday MOVES inventory mode run.

The emissions rate annualization factors were then calculated by dividing the annual emissions rates (including any necessary units conversion factors) by the summer weekday emissions rates. In those cases where annual emissions rates existed but summer weekday rates did not, the emissions rate annualization factor was set to zero, which caused the annual emissions rate to be used in the annual emissions calculation procedure.

Annual Activity and Emissions Calculations

The summer weekday inventory output consists of two formats: the standard tab-delimited format (activity and emissions by pollutant, process, SUT/fuel type, and road type) and the SCC tab-delimited format (VMT and emissions by pollutant and SCC). The SCC output is a re-aggregated, re-coded, very condensed portion of the standard format inventory data (e.g., SCC file sizes less than five percent of standard format output files). The SCC format excludes hourly data (keeps only day totals), drops off-network activity (keeps only VMT activity), aggregates particular pollutants (e.g., brakewear, tirewear, exhaust PM), aggregates VMT to SUT and fuel type totals, aggregates emissions to totals by pollutant, SUT and fuel type, and re-codes the results. For the annual inventories, both of the standard and SCC formats were additionally required. First the summer weekday inventories were annualized, producing the annual inventories in the standard output format. Using the SCC format procedure consistent with the summer weekday inventories, the annual inventories in SCC format were produced.

For the standard tab-delimited format, the annual activity was calculated by multiplying the 24-hour activity from the summer weekday standard tab-delimited activity and emissions file by the appropriate activity factor. Annual activity was calculated for VMT, SHI, APU hours, starts, and SHP.

The annual emissions were additionally calculated using the 24-hour emissions from the summer weekday standard tab-delimited activity and emissions file. For each pollutant, the annual emissions were calculated for each process by multiplying the summer weekday emissions by the appropriate activity factor and emissions rate annualization factor. In the case where the emissions rate annualization factor was zero and the annual emissions rate was greater than zero, the annual emissions were calculated by multiplying the appropriate annual activity by the annual emissions rate. The composite pollutant emissions were additionally calculated by summing the emissions for each process associated with the pollutant.

For the SCC tab-delimited format annual inventories, the annual standard tab-delimited activity and emissions were re-aggregated and re-coded in the same manner as was performed for the summer weekday inventories.

Conversion of Annual Emissions Inventories to XML Format

TTI converted the annual emissions (CAPs and HAPs) and activity results for each county to a format compatible for uploading to the TCEQ's TexAER based on the EPA's EIS NEI CERS XML format, which uses EPA's EIS inventory data codes, using the same procedures as the conversion of the 24-hour weekday emissions and activity. Particular MOVES pollutants required aggregation and re-coding for EIS compatibility (i.e., combining gas and particle PAHs; combining the three Mercury compounds; and combining PM from exhaust, brakewear, and tirewear). Each run produced an LST file (execution information, input/output file listings, input summaries, and input and output totals summaries with calculated differences for QA checks), the XML file, and one output summary of SCC-labeled inventory data in a tab-delimited text file form for each county included in the XML formatting run. All these files were included in the electronic data submittal (see Appendix A for more details).

ADDITIONAL CDBS FOR MOVES INVENTORY MODE

TTI developed two extra sets of CDBs for each county consistent with the emissions inventory data that may be used with MOVES in the inventory mode: one set of summer weekday CDBs and one set of annual CDBs. These inventory mode CDBs were designed to input to MOVES the appropriate activity data (daily for the summer weekday CDBs and annual for the annual CDBs), and with the appropriate MRSs, produce summer weekday inventory output consistent with, but not necessarily identical to, the summer weekday link-based and annual inventories. TTI additionally produced the annual inventory mode CDBs using the CDB names and the set of MOVES tables specified in EPA instructions for on-road input submittals for the 2017 NEI.[26]

The summer weekday inventory CDBs include the 26 input data tables shown in Table 41 along with corresponding data sources. The inventory CDBs include 20 of 21 (sourcetypeage is not used) MOVES tables used in the link-based analysis rates mode CDBs (see Table 31), replace the other rates mode CDB table (hpmsvtypeyear) with the sourcetypedayvmt table, and adds five more tables, hotellinghours, sourcetypeage, starts, monthofanyyear, and dayofanyweek.

The summer weekday inventory mode CDB data source categories are:

- Rates CDB (mainly local data directly from the link-based inventory rates CDBs);
- MOVESactivityInputBuild utility output (for activity inputs from link-based inventory);
- VehPopulationBuild utility output (for vehicle population estimates); and
- Adjusted MOVES defaults (for activity allocation factors modified as needed to produce daily output from daily activity input).

The inventory development utilities descriptions, to include MOVESacivityInputBuild and VehPopulationBuild utilities, are included in Appendix B.

[26] The on-road inputs submittal guidance is in *Instructions for Submitting ONROAD Inputs for the 2017 NEI,* EPA, July 31, 2018.

Table 41. Summer Weekday MOVES Inventory Mode CDB Tables and Data Sources.

Table	Data Source[1]
avft	Rates CDB
avgspeeddistribution	MOVESactivityInputBuild utility output
county	Rates CDB[1]
countyyear	Rates CDB[1]
dayofanyweek	MOVES default – with update: noOfRealDays = 1
dayvmtfraction	Rates CDB – with updates: dayVMTFraction = 1 (dayID = 5), dayVMTFraction = 0 (dayID = 2)
fuelsupply	Rates CDB
fuelformulation	Rates CDB
hotellingactivitydistribution	Rates CDB
hotellinghours	MOVESactivityInputBuild utility output
hourvmtfraction	MOVESactivityInputBuild utility output
imcoverage	Rates CDB[1]
monthofanyyear	MOVES default – with update: noOfDays = 7
monthvmtfraction	Rates CDB with update: monthVMTFraction = 1 (monthid = 7)
roadtype	MOVESactivityInputBuild utility output
roadtypedistribution	MOVESactivityInputBuild utility output
sourcetypeage	MOVESactivityInputBuild utility output (relativeMAR adjusted for local VMT mix – travel fractions calculated using relativeMAR adjusted to match 24-hour VMT from link-level inventory)
sourcetypeagedistribution	Rates CDB
sourcetypedayvmt	MOVESactivityInputBuild utility output
sourcetypeyear	VehPopulationBuild utility output
starts	MOVESactivityInputBuild utility output
state	Rates CDB
year	Rates CDB
zone	Rates CDB[1]
zonemonthhour	Rates CDB[1]
zoneroadtype	Rates CDB[1]

[1] Note that for virtual link counties, the "Rates CDB" data source is of the representative county for the county group emissions rates development process. For virtual link counties, county information taken from the Rates CDBs (e.g., such as countyid or zoneid in county, countyyear, zone, zonemonthhour, zoneroadtype, imcoverage) was updated from representative county to the actual individual county of the MOVES summer weekday inventory mode CDB created.

TTI initially created the annual inventory mode CDBs containing 24 of the 26 same input data tables as the summer weekday inventory CDBs (excluded the monthofanyyear and dayofanyweek tables that are not required for annual inventory mode CDBs). The EPA's 2017 NEI on-road inputs submittal instructions required 13 additional (empty) tables and removal of one table (sourcetypeage) for 36 total tables. TTI adjusted the set of tables (added the 13 and dropped the one), as required, and named the annual CDBs as additionally specified in the guidance. Table 42 shows the annual inventory CDB tables and data sources.

The annual inventory mode CDB data source categories are:

- CDBs from the MOVES emissions rate runs used in developing the seasonal weekday, link-based inventories (mainly local data from the link-based inventory analysis rates CDBs, which contain summer and winter data);
- MOVESactivityInputBuild utility output (for activity inputs built from applicable link-based inventory data);
- VehPopulationBuild utility output (for vehicle population estimates);
- Local data (2007-2016 ATR data by TxDOT district to build day VMT fractions and month VMT fractions); and
- Annual activity from the activity annualization procedures.

Table 42. Annual MOVES Inventory Mode CDB Tables and Data Sources.

Table[1]	Data Source
avft	Rates CDB
avgspeeddistribution	MOVESactivityInputBuild utility output for dayID 5 and dayID 2
county	Rates CDB[2]
countyyear	Rates CDB[2]
dayvmtfraction	Local Data (see Appendix J)
fuelsupply	Rates CDB with monthID 1 data for months 1-3, 10-12; monthID 7 data for months 4-9
fuelformulation	Rates CDB
hotellingactivitydistribution	Rates CDB
hotellinghours	Annual activity[3]
hourvmtfraction	Local Data (see Appendix J)
hpmsvtypeyear	Annual activity[3]
imcoverage	Rates CDB[2]
monthvmtfraction	Local Data (see Appendix J)
roadtype	MOVESactivityInputBuild utility output
roadtypedistribution	MOVESactivityInputBuild utility output
sourcetypeagedistribution	Rates CDB
sourcetypeyear	VehiclePopulationBuild utility output
starts	Annual activity[3]
state	Rates CDB
year	Rates CDB
zone	Rates CDB[2]
zonemonthhour	Rates CDB[2] with monthID 1 data for months 1-3, 10-12; monthID 7 data for months 4-9
zoneroadtype	Rates CDB[2]

[1] Per EPA NEI instructions, these 13 empty tables not shown were additionally included: auditlog, emissionratebyage, fuelsupplyyear, fuelusagefraction, hpmsvtypeday, importstartsopmodedistribution, onroadretrofit, sourcetypedayvmt, sourcetypeyearvmt, startshourfraction, startsmonthadjust, startsperday, and startssourcetypefraction.

[2] For virtual link counties, the “Rates CDBs” are for county groups represented by one countyID. County information taken from these Rates CDBs (such as countyid or zoneid in county, countyyear, zone, zonemonthhour, zoneroadtype, imcoverage) were updated for the county of the MOVES inventory mode CDB created.

[3] From the activity annualization procedures.

TTI built the MOVES inventory mode CDBs, checked that each one contained all the required tables, and ensured they were populated as intended. These MOVES inventory mode

CDBs along with the MySQL scripts used to create them, were provided as a part of the electronic data submittal (see Appendix A).

QUALITY ASSURANCE

Analyses and results were subjected to appropriate internal review and quality assurance and quality control (QA/QC) procedures, including independent verification and reasonableness checks. All work was completed consistent with applicable elements of American Society for Quality, American National Standard ASQ/ANSI: E4:2014: *Quality Management Systems for Environmental Information and Technology Programs – Requirements with Guidance for Use,* February 2014, and the TCEQ Quality Management Plan.

The Quality Assurance Project Plan (QAPP) category and project type most closely matching the intended use of this analysis are QAPP Category II (for important, highly visible agency projects involving areas such as supporting the development of environmental regulations or standards) and modeling for NAAQS Compliance. Internal review and quality control measures consistent with the QA category and project type-specific requirements provided in *Guidance for Quality Assurance Project Plans for Modeling*, EPA QA/G-5M,[27] along with appropriate audits or assessments of data and reporting of findings, were employed. These include but are not limited to the elements outlined, per *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5),[28] in the following description.

A. Project Management

The project management was as listed previously in the Acknowledgments section.

The definition and background of the problem addressed by this project, the project/task description, and project documents and records produced are as described previously in the Purpose and Background sections. No special training or certifications were required. The TTI project manager assured that the appropriate project personnel had and used the most current, approved version of the QAPP.

After receiving the Notice to Commence (NTC) from the TCEQ, the TTI project manager provided a detailed pre-analysis plan to the TCEQ project manager for review and concurrence. Upon concurrence of the pre-analysis plan, the TTI project manager distributed the pre-analysis plan to the TTI inventory developers for use in both the inventory development and QA review process. TTI maintains records of the project QA checks as a part of the project archive, for at least five years.

The objective was to produce the emissions inventory products of the quality suited to their purpose as specified (i.e., periodic emissions inventories and MOVES CDBs under the AERR to support the EPA's comprehensive three-year cycle NEI), in accordance with the appropriate guidance and methods documents as referenced, as detailed in the pre-analysis plan, and in consultation with the TCEQ project manager.

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[27] PDF available at: https://www.epa.gov/sites/production/files/2015-06/documents/g5m-final.pdf.
[28] PDF available at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf.

Basic criteria were used to assure that the acceptable quality of the product was met – product developers verified the process and product were as specified, to include:

- The product met the purpose of the emissions analysis (i.e., 2017 on-road mobile source portion of the 2017 periodic year emissions inventories and MOVES CDBs fulfilling requirements for Texas under the AERR and supporting the EPA's comprehensive three-year cycle NEI);
- The full extent of the modeling domain was included (i.e., analysis year, geographic coverage, seasonal periods, days, sources, pollutants);
- Agreed methods, models, tools, and data were used (i.e., as in the detailed pre-analysis plan);
- The required output data sets were produced in the appropriate formats in accordance with the pre-analysis plan;
- Any deficiencies found during development and end-product quality checks (as discussed in QAPP Part D) were corrected; and
- Aggregate emissions estimate results were comparable with available, similarly produced emissions estimates.

B. Measurement and Data Acquisition

Note that no sampling of data was involved in the emissions inventory development, thus only existing data (non-direct measurements) were used for this project.

The data needed for project implementation were in the categories needed for development of emissions rate model inputs and adjustment factors, and for development of the activity inputs for external emissions calculations. These emissions factor model inputs and activity inputs were developed using data sources as outlined previously and/or methods and procedures as detailed in the references listed, and as provided in the pre-analysis plan.

All data used either as direct input or to produce inputs (e.g., to the MOVES model or to TTI's emissions inventory development utilities used, which were listed in the pre-analysis plan) were reviewed by TTI for suitability before use. The data sets for the project were provided by TxDOT, a Metropolitan Planning Organization (MPO) or Council of Governments (COG), the TCEQ, and/or the EPA, and in most cases were QA'd by the providing agency. The pre-analysis plan lists the data to be used for the project. The data needed may include: HPMS data (from TxDOT's RIFCREC report); regional travel demand model data; speed model data; vehicle registration data; ATR data; vehicle classification count data; meteorological data; fuels data; MOVES emissions model data; extended idling activity data; and vehicle I/M program design data.

Any significant problems found during data review, verification, and/or validation (see QA criteria and methods discussion in Section D) were corrected, and the QA procedure was repeated until satisfied. Review of the annual inventory mode CDBs for the 2017 NEI indicated the initial set of tables included was not consistent with EPA specifications and neither were the CDB names. TTI revised the CDBs to bring them in line with the applicable specifications. No other significant problems were found.

Data Management: TTI emissions inventory data developers work as a closely coordinated team. The assigned staff used the same electronic project folder structure on their individual workstations. As various scripts, inputs, and outputs were developed in the emissions inventory development process, data were shared within the team for crosschecking via an intra-net, flash drive, or external hard drive. To perform the MOVES model runs, a computer cluster (multiple computer) configuration or individual workstation configuration was used. After input data were QA'd, depending on the size of the dataset, the datasets were backed up and stored in compressed files. These activities were performed throughout the process until the final products were produced.

For MOVES model runs to produce emissions factor look-up tables for the emissions inventories, all run files (MOVES model inputs and batch files) were produced on an individual workstation. After the MOVES input data and batch files (i.e., Run Files) were QA'd, they were either executed on an individual workstation, or they were copied (via external hard drive) to the cluster's Master computer and executed. Upon execution, completion, and error checking, the MOVES output databases were (for cluster runs first copied to an individual workstation) archived and processed further in preparation for input to the emissions calculations utility.

After the final product was completed, all the project data archives were compiled on a set of optical data discs (CD-ROM or DVD, depending on size), or on an external drive for very large project datasets. A complete archive of the project data is kept by TTI (the computer models and emissions inventory development utilities used in the process are included). An electronic data submittal package (containing the project deliverables as listed in Appendix A) was produced along with data description (on CD-ROM, DVDs, or external hard drive, depending on needed storage space) and delivered to the TCEQ.

C. Assessment and Oversight

The following assessments were performed.

- Verified that the overall scope was met (consistent with the intended purpose, for specified temporal resolution and geographic coverage, for specified sources, pollutants, and emissions processes).
- Checked that input data preparation, and model or utility execution instructions (e.g., run specifications, scripts, job control files [JCFs], command files) were prepared according to the plan.
- Checked that correct output data were produced (includes interim output [output that becomes input to a subsequent step in the inventory development process], as well as the final product). Records were kept of the checks performed.

In the case that any inconsistencies or deficiencies were found, the issue was directly communicated to the responsible staff for corrections (or the outside agency staff involved, if provided from outside of TTI, if needed). After a correction was made, the QA checks were performed again to ensure that the additional work resulted in the intended quality assured result, and the correction was noted in the QA record (process was performed until QA check was satisfied).

Any major problem was reported to the project manager and communicated to the project team as needed, as well as when the various data elements in the process passed QA checks and were ready for further processing according to the project pre-analysis plan. The project manager ensured that all of the QA checks performed were compiled, and maintained in the project archives.

In addition, technical systems audits were performed as appropriate. Audits of data quality at the requisite 25 percent level were performed for any data collected or produced as part of this study. QA findings were reported in both the draft and the final reports.

D. Data Validation and Usability

Erroneous or improper inputs at any point during the emissions inventory development process may produce resulting emissions estimates that are inaccurate and may not be suitable for their intended purpose. Adherence to the inventory process flow with performance of the integrated QA checks at each step of the process was of the utmost importance to ensure that the results met the project objectives.

The criteria for passing quality checks and the checks typically performed on each major inventory input component (i.e., input estimates of source activity, activity distributions, and emissions factors; as well as the resulting emissions estimates) are summarized in the following guidelines. These QA guidelines were used to ensure the development of emissions inventory estimates that were as accurate as possible and met the requirements of the TCEQ's intended use.

TTI verified that the overall scope of the emissions analysis has been met as prescribed in the pre-analysis plan, to include:

- Purpose of the emissions analysis (i.e., needed for the 2017 AERR requirements for Texas and to support EPA's 2017 NEI effort);
- Extent of the modeling domain (e.g., analysis years, geographic coverage, seasonal periods, alternate scenarios, days, sources, pollutants);
- Methods, models, and data used (e.g., default versus local input data sources); and
- Procedures and tools used and all required emissions output datasets were produced.

TTI performed checks on input data preparation, model or utility execution instructions (e.g., run specifications, scripts, JCFs, command files), and output, as appropriate to the component.

Input data preparation checks:

- Verified the basis of input data sets against the pre-analysis plan: Actual historical or latest available data, validated model, expected values or regulated limits, regulatory program design, model defaults, surrogates, professional judgment; checked aggregation levels.
- Data development: Depending on the procedure and particular input dataset, calculations were verified (e.g., re-calculated independently and compared with originally prepared

values – when spot-checking a series of results, included extremes and intermediate values).

- Completeness: Verified that input data sets were within the required dimensions, and all required fields were populated and properly coded or labeled.
- Format: Verified that formats were within required specifications (e.g., field positions, data types and formats, and file formats), if any.
- Reasonability checks: (discussed in the next section).
- Ensured that any inputs provided from external sources were quality assured, as listed previously.

Checks on model or utility execution instructions:

- Verified that the correct number of utility or model run specifications were prepared for each application (e.g., by year, county, season, day type).
- Verified that each utility or model run script included the correct modeling specifications for the application per applicable user guide (e.g., commands, input values, input and output file paths, output options).

Check for the successful completion of model and utility executions:

- Verified that the correct number of each type of output file was produced by the particular model or utility.
- Checked for any unusual output file sizes.
- Searched output for warnings and errors (e.g., utility listing files or model execution logs that contain error and warning records).
- Checked the summary information provided in output listing files for any unusual results.

Perform further checks for consistency, completeness, and reasonability of data output from model or utility applications:

- Verified that the data distributions and allocation factors produced or used sum to 1.0, as appropriate (e.g., hourly travel factors within a time period, proportion of travel by vehicle categories on a particular roadway category).
- Verified that the required data fields were present, populated, and properly coded or labeled; verified that data and file formats were within specifications.
- Verified that any activity, emissions rate, or emissions adjustments were performed as intended (e.g., seasonal activity factor, emissions control program adjustment).
- For data sets prepared with temporal or geographic variation, compared and noted whether directional differences were as expected (e.g., activity distributions between weekends/weekdays, vehicle mix, or average speeds between road types or time periods).

- Checked for consistency between data sets (e.g., compared detailed spatially and temporally disaggregated activity estimates [e.g., link VMT] to original aggregate totals, activity total summaries between utility applications [e.g., link-VMT producer and emissions calculator], and input hourly distributions versus hourly summaries from the link activity output data).
- Calculated county, 24-hour, aggregate emissions rates (from aggregate VMT and emissions output) and compared the rates between counties examining the results for outliers while assessing the reasonability of any relative and directional differences (e.g., qualify based on activity distributions by road type and speed, mix of vehicles by road type, meteorological variation, control program coverage). Compared the results to results from previous emissions analyses where available.
- Calculated county, 24-hour aggregate rates by vehicle class and compared between vehicle classes. Examined the results for consistent patterns.

Any additional data products required for the emissions analysis were subjected to the appropriate QA checks previously listed. Any issues found needing resolution were corrected and appropriate QA checks were performed until satisfied, ensuring the project results met the TCEQ requirements, i.e., as outlined in the Grant Activity Description (GAD), QAPP.

REFERENCES

Air Emissions Reporting Requirement. 40 C.F.R. Part 512008.

EPA. 1992. *Procedures for Emissions Inventory Preparation, Volume IV: Mobile Sources*, EPA 420-R-92-009, Office of Air Quality Planning and Standards.

EPA. 2001. Memorandum: Texas Low Emission Diesel (LED) Fuel Benefits. To Karl Edlund, EPA, Region VI, from Robert Larson, EPA, Office of Transportation and Air Quality (OTAQ), National Vehicle and Fuel Emissions Laboratory at Ann Arbor, MI. September 27, 2001.

EPA. 2002. *Guidance for Quality Assurance Project Plans for Modeling*, EPA QAjG-5M, EPA/240/R-02/007, Office of Environmental Information. December 2002.

EPA. 2009. *Emissions Inventory System Implementation Plan, Appendix 2, CERS and Examples,* available at https://www.epa.gov/air-emissions-inventories/2008-national- emissions-inventory-nei-documentation-draft.

EPA. 2009. *Emissions Inventory System Implementation Plan, Section 5, Submitting XML Data to the Emissions Inventory System (EIS),* available at https://www.epa.gov/air- emissions-inventories/2008-national-emissions-inventory-nei-documentation-draft.

EPA. 2009. *Emissions Inventory System Implementation Plan, Appendix 6, Reporting Code Tables,* available at https://www.epa.gov/air-emissions-inventories/2008-national- emissions-inventory-nei-documentation-draft.

EPA. 2009. *Emissions Inventory System Exchange: Flow Configuration Document, Version i.2b,* available at https://www.epa.gov/sites/production/files/201 4-07/documents/ configuration. Pdf.

EPA. 2015. *MOVES2014a Software Design and Reference Manual*, EPA420-B- 15-096, Assessment and Standards Division, Office of Transportation and Air Quality. November 2015.

EPA. 2015. *MOVES2014 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emissions Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-15-093, Transportation and Regional Programs Division, Office of Transportation and Air Quality. November 2015.

EPA. 2015. *MOVES2014a User Guide,* EPA-420-B-15-095, Assessment and Standards Division, Office of Transportation and Air Quality. November 2015.

EPA. 2016. *MOVES 2014a User Interface Reference Manual*, EPA-420-B-16-085, Assessment and Standards Division, Office of Transportation and Air Quality. July-November 2016.

EPA. 2017. *Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations*, EPA-454/B-17-002, Issued By: Office of Air Quality Planning and Standards, Air Quality Assessment Division, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. May 2017.

EPA. 2017. National Emissions Inventory (NEI) Documentation, available at https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-documentation.

ERG. 2017. *2017 Fuel Field Study, Final Report*, Eastern Research Group, Inc., work in progress, report number and publication date will be provided by the TCEQ Project Manager after August 31, 2017.

Texas A&M Transportation Institute. 2016. *TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUTL User's Guide*, August 2016.

APPENDIX A:
ELECTRONIC DATA SUBMITTAL DESCRIPTION

Texas On-Road 2017 AERR and Haps Inventory – Electronic Data Submittal Description

This appendix describes the MOVES2014a-based emissions inventories data files for eight areas (all 254 counties) TTI submitted to the TCEQ, per Proposal for Grant Activities No. 582-18-81284-08. TTI submitted the complete set of files in two parts. Part 1 (December 20, 2018) excluded the annual emissions inventory files. Part 2 (January 10, 2019) provided the annual inventory data files. The complete file-set described in this appendix includes:

- Seasonal weekday and annual emissions inventory data summaries:
  - Inventory tab-delimited text file outputs: a standard set by MOVES SUT (plus several extracted summaries from this file), and a set by SCC; and
  - XML file outputs: XML files (for upload to EPA's EIS and the TCEQ's TexAER), and tab-delimited summaries by SCC (from the XML results);
- MOVES run inputs: CDBs and Runspec files used in the MOVES runs, and MySQL scripts for building the CDBs; and
- Additional CDBs for inventory mode, including a set for EPA's 2017 NEI.

The 254 Texas counties are grouped by area and activity basis (TDM or HPMS). Seven areas (40 counties) are region-based. The other 214 counties are statewide-based. The regional method uses TDM activity data if available and finer detail in some MOVES inputs.

AERR Inventories – 254 Counties by Area and Activity Basis.

Area (Area Label)	TDM Counties (TDM Label)	HPMS Counties (VMT Label)
1. Austin Area (AUS)	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson (ATDM)	N/A
2. Beaumont-Port Arthur Area (BPA)	Hardin, Jefferson, Orange (BTDM)	N/A
3. Dallas Fort-Worth (DFW)	Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise (DTDM)	N/A
4. El Paso County (ELP)	El Paso (ETDM)	N/A
5. Houston-Galveston-Brazoria Area (HGB)	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller (HTDM)	N/A
6. San Antonio Area (SAN)	Bexar, Comal, Guadalupe, Kendall, Wilson (STDM)	N/A
7. Northeast Texas near-nonattainment area (TLM)	Gregg (LTDM), Smith (TTDM)	Harrison, Rusk, Upshur (HPMS)
8. Remainder of Texas (statewide Vlink)	(listed at end of appendix)	214 counties (HPMS)

Emissions Inventory Data Summaries

The county-level emissions inventory data files (inventory calculation utility output) were provided in zip files by area. Inventory data summary spreadsheets zip files were by period.

Emissions Inventory Types Summary

Area	Counties	County Inventories (Utility)[1]	
		Seasonal Weekday (EmsCalc)	Annual (EmsCalcAnn)
ELP	1	1 summer, 1 winter	1
AUS, BPA, DFW, HGB, SAN, TLM	39	39 summer	39
VLink (Remainder of State)	214	214 summer	214
Total	**254**	**255**	**254**

[1] The summer weekday inventory output and a set of annualization factors were input to the annual emissions calculations.

Summary Spreadsheets

The inventory extracts and summary spreadsheets were included in:

- AERR17_TX_ann_summaries_xls.zip; and
- AERR17_TX_wkd_summaries_xls.zip.

EmsCalc and EmsCalcAnn

The EmsCalc and EmsCalcAnn inventory output files were provided in zip files, a set of eight (by area) for each utility:

- AERR17_<area>_EmsCalcAnn_Output.zip; and
- AERR17_<area>_EmsCalc_Output.zip.

The EmsCalcAnn and EmsCalc output files are:

- o AERR17_<area>_<FIPS>_2017<period>_<VMTmodel>_ems.LST;
- o AERR17_<area>_<FIPS>_2017<period>_<VMTmodel>_ems.TAB; and
- o AERR17_<area>_<FIPS>_2017<period>_<VMTmodel>_sccoutput_ems.TAB.

Bastrop County inventory files, as an example, are:

EmsCalcAnn:

- o AERR17_AUS_48021_2017Ann_ATDM_ems.LST;
- o AERR17_AUS_48021_2017Ann_ATDM_ems.TAB; and
- o AERR17_AUS_48021_2017Ann_ATDM_sccoutput_ems.TAB.

EmsCalc:

- o AERR17_AUS_48021_2017swkd_ATDM_ems.LST;
- o AERR17_AUS_48021_2017swkd_ATDM_ems.TAB; and
- o AERR17_AUS_48021_2017swkd_ATDM_sccoutput_ems.TAB.

LST files record the run script, execution time, file locations, and various data summaries. Tab-delimited output file types are the standard (by MOVES SUT and fuel type) and SCC (by aggregations of MOVES SCCs) summaries. Weekday standard output includes hourly and 24-hour activity and emissions (pounds). Weekday SCC output is 24-hour results only. Annual "standard" and "SCC" outputs contain calendar year activity and emissions (tons) results.

The activity estimates in TAB files are by SUT/fuel type and by road type (or off-network):

- Roadway-based - VMT, VHT, (not in annual), Speed (not in annual); and
- Off-network-based - SHP, Extended Idle Hours (SHI), APU Hours, Starts.

The pollutants are tabulated by SUT/fuel type and by road types for the VMT model or as off-network depending on the emissions process and activity type (e.g., VMT or SHP for evaporative). In addition to MOVES emissions processes, "composite" (pollutant totals) are included. The weekday and annual inventories include the same pollutants and processes. HAPs were additionally included in the weekday runs (needed for input to the annual emissions calculations.)

TabFileTotals and TabFileTotalsAnn

Six tab-delimited inventory summary files were produced by area for the seasonal weekday period ("wkd") inventories and for annual ("ann") four summary files were produced. The summaries (EmsCalc and EmsCalcAnn output extracts) were provided in zip file sets by area:

- AERR17_<area>_TabFileTots.zip; and
- AERR17_<area>_TabFileTotsAnn.zip.

The files include:

- o AERR17_<area>_<FIPS group[29]>_2017<period>_tabtots.LST; and
- o AERR17_<area>_<FIPS group[1]>_2017<period>_tabtots_***????***.TAB.

Where the inventory summary types "***????***" are:

- o "tabtots" (24-hr and annual totals) (wkd and ann period files);
- o "tabtots_Hr" (hourly totals) (wkd files only);

[29] "FIPS group" is for VLink area files only. To reduce the file size, the TabFileTotalsAnn summaries for the 214 VLink counties were produced in six FIPS groups: 48001-48099, 48101-48199, 48201-48299, 48301-48399, 48401-48499, and 48501-48507.

- o "tabtots_HrST" (hourly, SUT/fuel type totals) (wkd files only);
- o "tabtots_RdType" (hourly wkd and ann road type totals) (wkd and ann period files);
- o "tabtots_ST" (24-hr and ann SUT/fuel type totals) (wkd and ann period files);
- o "tabtots_24hourRdTypeST" (24-hr, road type, SUT/fuel type totals) (wkd files only); and
- o "tabtots_RdTypeST" (annual, road type, SUT/fuel type totals) (ann files only).

XML Format

XML summaries (EIS CERS XML inventory data files with current SCCs and pollutant codes consistent with EPA's EIS and the TCEQ's TexAER) were produced for seasonal weekday and annual. The summaries use 10-digit SCCs providing data at the source type and fuel type level. Only VMT activity is reported. The SCC for gasoline passenger cars, for example, is:

2201210080 - On-road processes excluding refueling:

22 – mobile sources;

01 – highway vehicles, gasoline (MOVES fueltypeID);

21 – passenger car (MOVES SourcetypeID);

00 – all road types; and

80 – all on-network and off-network processes (except refueling).

Particular MOVES pollutants required aggregation and re-coding for EIS compatibility (e.g., combining gas and particle PAHs; three Mercury compounds; PM from exhaust, brakewear and tirewear). For summer weekday and annual, the 254 counties were divided into four parts (sequentially first by area, then by FIPS) - first 72, next 60, next 60, and last 62. Each run produced the three output file types (LST, XML, and TAB). Summer weekday Part 1 files for example, are:

- o MOVESsccXMLformat_AERR17_MVS14a_swkd_Part1_72.lst
- o MOVESsccXMLformat_AERR17_MVS14a_swkd_Part1_72.xml
- o MOVESsccXMLformat_AERR17_MVS14a_swkd_Part1_72_48021_summary.tab
- o MOVESsccXMLformat_AERR17_MVS14a_swkd_Part1_72_48053_summary.tab

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- o MOVESsccXMLformat_AERR17_MVS14a_swkd_Part1_72_48075_summary.tab

Annual and El Paso winter weekday were named similarly (but with "annual" and "wwkd" in filenames).

The LST provides a listing of the utility execution, the XML files contain the EIS CERS xml-formatted inventory data for all counties in the run (using 2017 NEI SCCs and pollutant codes consistent with EPA's EIS and the TCEQ's TexAER), and output tab files (one per county in the run) contains the county summary inventory data by SCC, from the XML output file. Nine runs were performed, four parts each for summer weekday and annual, and one run for the

El Paso winter weekday. All the weekday and annual XML formatting output files were included in:

- AERR17_TX_wkd_XML.zip; and
- AERR17_TX_ann_XML.zip.

A spreadsheet file "AERR17_EmsCalcAnn_SCCpoll-to-EISpoll.xlsx" showing the conversions to EIS (NEI) pollutant codes from the EmsCalcAnn utility Tab-delimited SCC output pollutant codes (with aggregations of some MOVES pollutantIDs, as mentioned previously) was included in the "ann" zip file.

Summer (and El Paso Winter)Weekday Emissions Factor Data

Emissions factors were developed by county for regional analyses (see the table of 40 regional counties at the end of this appendix); the statewide method was used to produce rates by county group (see the table of 214 VLink counties at the end of this appendix). The rates mode CDBs input to the MOVES rates mode runs for the rates-per-activity method external link-based emissions inventory calculations were populated with a combination of local data and MOVES default data. The following emissions factor development files (used in conjunction with the MOVES default database, i.e., MOVESDB20161117) were provided:

- MOVES MRS input files;
- MOVES CDB inputs;
- MySQL scripts for building CDBs; and
- Local data files used to populate CDB input tables.

MOVES Inputs

Regional county level input files include 41 MRS files (40 swkd and 1 wwkd) and 40 CDBs (that include both summer and winter data denoted by "sw" in CDB names). Statewide county group level input files include 34 MRS files and 34 CDBs.

The files were provided in eight zip files by area:

- AERR17_<area>_er_cdbsMRSsSQL.zip.

The MOVES rates mode run MRS filenames and associated CDB names and scripts are:

- MVS14A_AERR17_<area or district><FIPS>_<period-day type>_ER.MRS;
- MVS14A_AERR17_<area or district><FIPS>_sw_ER_CDB_in; and
- MVS14A_AERR17_<area or district><FIPS>_sw_ER_CDB_in.SQL.

For example, the MOVES emissions rate run MRS files and associated CDBs for El Paso winter weekday and for a select county group summer weekday are:

- MVS14A_AERR17_ELP48141_wwkd_ER.MRS;
- MVS14A_AERR17_D0148033_swkd_ER.MRS;
- MVS14A_AERR17_ELP48141_sw_er_cdb_in; and
- MVS14A_AERR17_D0148033_sw_er_cdb_in.

"Area" is for the seven regional analyses (AUS, BPA…. TLM). District is a label for TxDOT district (D01 Abilene, D02 Amarillo…. D25 Yoakum) in statewide analyses. For statewide analyses "FIPS" is the code for the county representing the county group.

Local Input Data Used in Rates CDBs – Age distributions and fuel fractions; fuel formulations and supply; hotelling activity distribution; I/M program coverage; meteorological data files were provided with "readme" files in:

- AERR17_TX_er_LocalMOVESin.zip.

TxLED Adjustment Factors – TxLED NO_x adjustment factors used to post-process diesel source type NO_x emissions to account for TxLED effects were provided in the file:

- AERR17_TX_er_TxLEDfactors.zip.

Annual Emissions – Rates and Activity Annualization Factors

MOVES Inputs

MOVES runspecs and CDB inputs for production of MOVES inventory mode "annual" and "swkd" output used to compute emissions rate annualization factors input to the annual emissions calculations.

Files were provided in:

- AERR17_TX_sw_swkd_ei_cdbsMRSsSQL.zip (generalized annual "sw" and summer weekday "swkd" MRSs for each of the 74 counties/county groups, 74 CDBs with seasonal data for both "sw" and "swkd" runs, CDB scripts, and local monthvmtfraction inputs data file and database [other inputs are same as in rates mode runs CDBs]).

MOVES inventory mode run MRS filenames and associated CDB names and scripts are:

- MVS14A_AERR17_<area or district><FIPS>_sw_EI.MRS;
- MVS14A_AERR17_<area or district><FIPS>_swkd_EI.MRS;
- MVS14A_AERR17_<area or district><FIPS>_sw_EI_CDB_in; and
- MVS14A_AERR17_<area or district><FIPS>_sw_EI_CDB_in.SQL.

For example, MOVES inventory run MRS files and CDB for the annual emissions rate factors development process for Bastrop County summer weekday are:

- MVS14A_AERR17_AUS48021_SW_EI.MRS;
- MVS14A_AERR17_AUS48021_SWKD_EI.MRS; and
- MVS14a_AERR17_AUS48021_sw_ei_cdb_in (for "swkd" and "annual" runs).

To produce annual emissions rate factors, annual (with summer and winter seasonality and both MOVES day types) and summer weekday runs were made. Inventory outputs were post-processed into annual average daily and average summer weekday rates. Annual emissions rate factors were calculated as the emissions rate quotient "Ann"/"Swkd." No TxLED adjustments were made (in both numerator and denominator would essentially result in factor of unity).

Emissions Rate Annualization Factors

One annual rate factor utility run per 74 counties/countygroups output the emissions rate annualization factors used in the calculations that converted summer weekday to annual emissions. Outputs were provided in:

- AERR17_TX_ratesannfacts.zip.

Output files were named similarly to previous rate development files listed, such as:

- MVS14a_AERR17_AUS48021_RatesAnnFactCalc.lst; and
- MVS14a_AERR17_AUS48021_RatesAnnFactCalc.tab.

The MOVES inventory outputs were input to the annual rate factor calculation utility. Each run produced one LST and one TAB output file. The LST file lists the run script, input/output files, run times, warnings, input/output summary information and the TAB file contains the "annual" and seasonal weekday emissions and activity from the MOVES inventory output, and the calculated annual average daily and seasonal weekday emissions rates, and finally the resulting annual average day rate divided by the seasonal weekday rate, or annual emissions rate factor. The factors are by pollutant, process, SUT, fuel type, AnnFact road type (restricted access, unrestricted access, and offnetwork), and activity type.

Annual Activity Factors

The summer weekday activity annualization factors input to MOVES2014a_EmsCalcAnn were additionally provided. These factors were used to convert summer weekday inventory activity to annual activity and in combination with the annual emissions rate factors, to convert summer weekday inventory emissions to annual emissions. Annualization factors input files to EmsCalcAnn for hotelling, starts, and VMT activity are by area, including the factors for all counties for the area in each file. SHP activity annualization factor files are by county. Files are:

- AERR17_<area>_2017_HotellingAnnFacts.tab;
- AERR17_<area>_2017_StartsAnnFacts.tab;
- AERR17_<area>_2017_VMTannFact.tab; and
- AERR17_<area>_<FIPS>_2017_SHPannFacts.tab.

These activity annualization factor files were provided in “area” zip files along with several other files concurrently produced for the annual inventory mode CDBs, listed in the next section.

Additional CDBS

TTI initially developed two extra sets of CDBs for each of the 254 counties consistent with the link-based emissions inventory data for use with MOVES in the inventory mode: one set of summer weekday CDBs (and an El Paso winter weekday) and one set of annual CDBs. The MySQL scripts written and data files used to produce these CDBs were provided with the CDBs. These inventory mode CDBs were designed to input the appropriate activity data (daily for the seasonal weekday CDBs and annual for the annual CDBs), and with the appropriate MRSs, produce seasonal weekday and annual output inventory estimates consistent with, but not necessarily identical to, the seasonal weekday and annual link-based inventories. TTI prepared an additional annual CDBs set in accordance with EPA’s 2017 NEI specifications, as an update of the initial annual CDBs.[30]

The extra seasonal weekday and initial annual CDBs and scripts were provided in zip file sets for each of the eight areas, named:

- AERR17_<area>_ann_inv_mode_CDBsSQLdata.zip (annual); and
- AERR17_<area>_wkd_inv_mode_CDBsSQLdata.zip (weekday).

The extra CDBs updated to EPA’s 2017 NEI specifications were provided in one zip file:

- AERR17_TX_NEI_CDBs.zip.

MOVESactivityinputbuild-Produced Inventory Mode CDB Input Data – TTI provided the following output text files (data formatted for input to MOVES) from 255 utility runs:

- “AERR17_<area>_<FIPS>_2017swkd_MOVESactInBld_***????***.tab” (plus an El Paso “wwkd”).

Where ***????*** is data “label” (specifying the associated MOVES table input data):[31]

- “avgspddist” (avgspeeddistribution);
- “dayvmtfraction” (dayvmtfraction);
- “hotellinghourstable” (hotellinghours);
- “hpmsvtypeday” (hpmsvtypeday);

[30] These CDBs include all the tables listed in Table 1 of EPA’s “Instructions for Submitting ONROAD Inputs for the 2017 NEI” (July 31, 2018). Update of the initial CDBs involved adding several (empty) tables and renaming the databases as prescribed for the 2017 NEI.
[31] TTI provided all of the MOVESactivitybuild output data files listed, however not all were used.

- “hrvmtfract” (hourvmtfraction);
- “monthvmtfraction” (monthvmtfraction);
- “roadtypetable” (roadtype);
- “rtdist” (roadtypedistribution);
- “sourcetypeage_adjMAR” (sourcetypeage);
- “sourcetypedayvmt” (sourcetypedayvmt);
- “StartsTable” (starts);
- “state” (state);
- “year” (year);
- “zone” (zone); and
- “zoneroadtype” (zoneroadtype).

Other files include the output “*.LST” file, and VMT and VHT summary files:

- “linkVHTsumm” (VHT by hour, roadtype, areatype, and avgspeedbinID); and
- “linkVMTsumm” (VMT by hour, roadtype, and areatype).

The files were provided in:

- AERR17_VLink_wkd_MOVESactInBld_out.zip.

Vehpopulationbuild-Produced Inventory Mode CDB Input Data – The Vehpopulationbuild utility (254 runs) produced the MOVES sourcetypeyear table inputs (source type populations), as well as vehicle registration and fuel-type-specific source-type population estimate summaries.

- “AERR17_<area>_<FIPS>_VehPop_2017_***????***.tab.”

Where ***????*** is data “label” (specifying MOVES input data or summary data table):

- “sourcetypeyear” (MOVES sourcetypeyear input data);
- “RegData” (registrations summary by type/model year);
- “StFtPop” (SUT/FT population summaries); and
- A *.LST was output for each run.

The files were provided in:

- AERR17_VLink_VehPop_Out.zip.

MOVESfleetinputbuild-Produced Inventory Mode CDB Input Data – The (age distribution and fuel engine fraction) input data files were included in the "Summer (and El Paso Winter) Weekday Emissions Factor Data" section.

Additional Tables Needed for Annual CDBs – Other than various MOVES data tables from those previously listed, the following data tables were developed specifically for use in the annual CDBs:

- "AERR17_<area>_<FIPS>_2017_***????***.tab."

Where ***????*** is data "label" (specifying MOVES input data table):

- "ann_dayvmtfraction" (MOVES dayvmtfraction table input data);
- "ann_monthvmtfraction" (MOVES monthvmtfraction table input data);
- "hourvmtfractionTableAnn" (MOVES hourvmtfraction table input data);
- "averagespeeddistributionTableAnn" (MOVES avgspeeddistribution table input data);
- "hpmsvtypeyearAnn" (MOVES hpmsvtypeyear table input data);
- "startsTableAnn" (MOVES starts table input data); and
- "hotellinghoursTableAnn" (MOVES hotellinghours table input data).

With each output TAB file an LST was included. Files were provided in:

- AERR17_<area>_Annfacs_MOVESAnnBlds_out.zip (this zip file additionally includes the activity annualization factor files previously listed).

Regional Counties (40) Information – Emissions Factor Development.

County ID[1]	County Name	Area Label	District Name	Composite Code[2]
48021	Bastrop	AUS	Austin	D04R2
48053	Burnet	AUS	Austin	D04R1
48055	Caldwell	AUS	Austin	D04R2
48209	Hays	AUS	Austin	D04R2
48453	Travis	AUS	Austin	D04R2ITW
48491	Williamson	AUS	Austin	D04R2ITW
48199	Hardin	BPA	Beaumont	D05R5
48245	Jefferson	BPA	Beaumont	D05R5
48361	Orange	BPA	Beaumont	D05R5
48085	Collin	DFW	Dallas	D10R4ID4
48113	Dallas	DFW	Dallas	D10R4ID4
48121	Denton	DFW	Dallas	D10R4ID4
48139	Ellis	DFW	Dallas	D10R2IXD
48221	Hood	DFW	Fort Worth	D12R2
48231	Hunt	DFW	Paris	D18R2
48251	Johnson	DFW	Fort Worth	D12R2IXD
48257	Kaufman	DFW	Dallas	D10R2IXD
48367	Parker	DFW	Fort Worth	D12R2IXD
48397	Rockwall	DFW	Dallas	D10R2IXD
48439	Tarrant	DFW	Fort Worth	D12R4ID4
48497	Wise	DFW	Fort Worth	D12R2
48141	El Paso	ELP	El Paso	D11R3IEL
48039	Brazoria	HGB	Houston	D13R4IH5
48071	Chambers	HGB	Beaumont	D05R4
48157	Fort Bend	HGB	Houston	D13R4IH5
48167	Galveston	HGB	Houston	D13R4IH5
48201	Harris	HGB	Houston	D13R4IH5
48291	Liberty	HGB	Beaumont	D05R4
48339	Montgomery	HGB	Houston	D13R4IH5
48473	Waller	HGB	Houston	D13R4
48029	Bexar	SAN	San Antonio	D21R2
48091	Comal	SAN	San Antonio	D21R2
48187	Guadalupe	SAN	San Antonio	D21R2
48259	Kendall	SAN	San Antonio	D21R1
48493	Wilson	SAN	San Antonio	D21R2
48183	Gregg	TLM	Tyler	D22R2
48203	Harrison	TLM	Atlanta	D03R2
48401	Rusk	TLM	Tyler	D22R2
48423	Smith	TLM	Tyler	D22R2
48459	Upshur	TLM	Atlanta	D03R2

[1] The 40 regional, county-level modeling files are identified by the FIPS code of each county.

[2] The composite code (last column) identifies the associated TxDOT district (i.e., D1 through D25), fuel region (i.e., R1 through R6, consistent with the six MOVES fuel regions for Texas), and I/M program (e.g., IEL, IH5), if any. TxLED NO_x adjustments were made to TxLED fuel region counties (all counties in R2, R4, and R5 regions).

Statewide 214 Counties: 34 County Groups – Emissions Factor Analysis.

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48033	Borden	Abilene	D01R1	Borden	48033
48033	Borden	Abilene	D01R1	Callahan	48059
48033	Borden	Abilene	D01R1	Fisher	48151
48033	Borden	Abilene	D01R1	Haskell	48207
48033	Borden	Abilene	D01R1	Howard	48227
48033	Borden	Abilene	D01R1	Jones	48253
48033	Borden	Abilene	D01R1	Kent	48263
48033	Borden	Abilene	D01R1	Mitchell	48335
48033	Borden	Abilene	D01R1	Nolan	48353
48033	Borden	Abilene	D01R1	Scurry	48415
48033	Borden	Abilene	D01R1	Shackelford	48417
48033	Borden	Abilene	D01R1	Stonewall	48433
48033	Borden	Abilene	D01R1	Taylor	48441
48011	Armstrong	Amarillo	D02R1	Armstrong	48011
48011	Armstrong	Amarillo	D02R1	Carson	48065
48011	Armstrong	Amarillo	D02R1	Dallam	48111
48011	Armstrong	Amarillo	D02R1	Deaf Smith	48117
48011	Armstrong	Amarillo	D02R1	Gray	48179
48011	Armstrong	Amarillo	D02R1	Hansford	48195
48011	Armstrong	Amarillo	D02R1	Hartley	48205
48011	Armstrong	Amarillo	D02R1	Hemphill	48211
48011	Armstrong	Amarillo	D02R1	Hutchinson	48233
48011	Armstrong	Amarillo	D02R1	Lipscomb	48295
48011	Armstrong	Amarillo	D02R1	Moore	48341
48011	Armstrong	Amarillo	D02R1	Ochiltree	48357
48011	Armstrong	Amarillo	D02R1	Oldham	48359
48011	Armstrong	Amarillo	D02R1	Potter	48375
48011	Armstrong	Amarillo	D02R1	Randall	48381
48011	Armstrong	Amarillo	D02R1	Roberts	48393
48011	Armstrong	Amarillo	D02R1	Sherman	48421
48037	Bowie	Atlanta	D03R2	Bowie	48037
48037	Bowie	Atlanta	D03R2	Camp	48063
48037	Bowie	Atlanta	D03R2	Cass	48067
48037	Bowie	Atlanta	D03R2	Marion	48315
48037	Bowie	Atlanta	D03R2	Morris	48343
48037	Bowie	Atlanta	D03R2	Panola	48365
48037	Bowie	Atlanta	D03R2	Titus	48449

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48031	Blanco	Austin	D04R1	Blanco	48031
48031	Blanco	Austin	D04R1	Gillespie	48171
48287	Lee	Austin	D04R2	Lee	48287
48031	Blanco	Austin	D04R1	Llano	48299
48031	Blanco	Austin	D04R1	Mason	48319
48241	Jasper	Beaumont	D05R2	Jasper	48241
48241	Jasper	Beaumont	D05R2	Newton	48351
48241	Jasper	Beaumont	D05R2	Tyler	48457
48049	Brown	Brownwood	D06R1	Brown	48049
48049	Brown	Brownwood	D06R1	Coleman	48083
48049	Brown	Brownwood	D06R1	Comanche	48093
48049	Brown	Brownwood	D06R1	Eastland	48133
48049	Brown	Brownwood	D06R1	Lampasas	48281
48049	Brown	Brownwood	D06R1	McCulloch	48307
48049	Brown	Brownwood	D06R1	Mills	48333
48049	Brown	Brownwood	D06R1	San Saba	48411
48049	Brown	Brownwood	D06R1	Stephens	48429
48041	Brazos	Bryan	D07R2	Brazos	48041
48041	Brazos	Bryan	D07R2	Burleson	48051
48041	Brazos	Bryan	D07R2	Freestone	48161
48041	Brazos	Bryan	D07R2	Grimes	48185
48041	Brazos	Bryan	D07R2	Leon	48289
48041	Brazos	Bryan	D07R2	Madison	48313
48041	Brazos	Bryan	D07R2	Milam	48331
48041	Brazos	Bryan	D07R2	Robertson	48395
48041	Brazos	Bryan	D07R2	Walker	48471
48041	Brazos	Bryan	D07R2	Washington	48477

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48045	Briscoe	Childress	D08R1	Briscoe	48045
48045	Briscoe	Childress	D08R1	Childress	48075
48045	Briscoe	Childress	D08R1	Collingsworth	48087
48045	Briscoe	Childress	D08R1	Cottle	48101
48045	Briscoe	Childress	D08R1	Dickens	48125
48045	Briscoe	Childress	D08R1	Donley	48129
48045	Briscoe	Childress	D08R1	Foard	48155
48045	Briscoe	Childress	D08R1	Hall	48191
48045	Briscoe	Childress	D08R1	Hardeman	48197
48045	Briscoe	Childress	D08R1	King	48269
48045	Briscoe	Childress	D08R1	Knox	48275
48045	Briscoe	Childress	D08R1	Motley	48345
48045	Briscoe	Childress	D08R1	Wheeler	48483
48007	Aransas	Corpus Christi	D09R2	Aransas	48007
48007	Aransas	Corpus Christi	D09R2	Bee	48025
48007	Aransas	Corpus Christi	D09R2	Goliad	48175
48249	Jim Wells	Corpus Christi	D09R6	Jim Wells	48249
48007	Aransas	Corpus Christi	D09R2	Karnes	48255
48249	Jim Wells	Corpus Christi	D09R6	Kleberg	48273
48007	Aransas	Corpus Christi	D09R2	Live Oak	48297
48007	Aransas	Corpus Christi	D09R2	Nueces	48355
48007	Aransas	Corpus Christi	D09R2	Refugio	48391
48007	Aransas	Corpus Christi	D09R2	San Patricio	48409
48349	Navarro	Dallas	D10R2	Navarro	48349
48043	Brewster	El Paso	D11R1	Brewster	48043
48043	Brewster	El Paso	D11R1	Culberson	48109
48229	Hudspeth	El Paso	D11R1	Hudspeth	48229
48043	Brewster	El Paso	D11R1	Jeff Davis	48243
48043	Brewster	El Paso	D11R1	Presidio	48377
48143	Erath	Fort Worth	D12R1	Erath	48143
48143	Erath	Fort Worth	D12R1	Jack	48237
48143	Erath	Fort Worth	D12R1	Palo Pinto	48363
48425	Somervell	Fort Worth	D12R2	Somervell	48425

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48127	Dimmit	Laredo	D14R1	Dimmit	48127
48131	Duval	Laredo	D14R6	Duval	48131
48127	Dimmit	Laredo	D14R1	Kinney	48271
48127	Dimmit	Laredo	D14R1	La Salle	48283
48127	Dimmit	Laredo	D14R1	Maverick	48323
48127	Dimmit	Laredo	D14R1	Val Verde	48465
48127	Dimmit	Laredo	D14R1	Webb	48479
48127	Dimmit	Laredo	D14R1	Zavala	48507
48017	Bailey	Lubbock	D15R1	Bailey	48017
48017	Bailey	Lubbock	D15R1	Castro	48069
48017	Bailey	Lubbock	D15R1	Cochran	48079
48017	Bailey	Lubbock	D15R1	Crosby	48107
48017	Bailey	Lubbock	D15R1	Dawson	48115
48017	Bailey	Lubbock	D15R1	Floyd	48153
48017	Bailey	Lubbock	D15R1	Gaines	48165
48017	Bailey	Lubbock	D15R1	Garza	48169
48017	Bailey	Lubbock	D15R1	Hale	48189
48017	Bailey	Lubbock	D15R1	Hockley	48219
48017	Bailey	Lubbock	D15R1	Lamb	48279
48017	Bailey	Lubbock	D15R1	Lubbock	48303
48017	Bailey	Lubbock	D15R1	Lynn	48305
48017	Bailey	Lubbock	D15R1	Parmer	48369
48017	Bailey	Lubbock	D15R1	Swisher	48437
48017	Bailey	Lubbock	D15R1	Terry	48445
48017	Bailey	Lubbock	D15R1	Yoakum	48501
48005	Angelina	Lufkin	D16R2	Angelina	48005
48005	Angelina	Lufkin	D16R2	Houston	48225
48005	Angelina	Lufkin	D16R2	Nacogdoches	48347
48005	Angelina	Lufkin	D16R2	Polk	48373
48005	Angelina	Lufkin	D16R2	Sabine	48403
48005	Angelina	Lufkin	D16R2	San Augustine	48405
48005	Angelina	Lufkin	D16R2	San Jacinto	48407
48005	Angelina	Lufkin	D16R2	Shelby	48419
48005	Angelina	Lufkin	D16R2	Trinity	48455

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48003	Andrews	Odessa	D17R1	Andrews	48003
48003	Andrews	Odessa	D17R1	Crane	48103
48003	Andrews	Odessa	D17R1	Ector	48135
48003	Andrews	Odessa	D17R1	Loving	48301
48003	Andrews	Odessa	D17R1	Martin	48317
48003	Andrews	Odessa	D17R1	Midland	48329
48003	Andrews	Odessa	D17R1	Pecos	48371
48003	Andrews	Odessa	D17R1	Reeves	48389
48003	Andrews	Odessa	D17R1	Terrell	48443
48003	Andrews	Odessa	D17R1	Upton	48461
48003	Andrews	Odessa	D17R1	Ward	48475
48003	Andrews	Odessa	D17R1	Winkler	48495
48119	Delta	Paris	D18R2	Delta	48119
48119	Delta	Paris	D18R2	Fannin	48147
48119	Delta	Paris	D18R2	Franklin	48159
48119	Delta	Paris	D18R2	Grayson	48181
48119	Delta	Paris	D18R2	Hopkins	48223
48119	Delta	Paris	D18R2	Lamar	48277
48119	Delta	Paris	D18R2	Rains	48379
48119	Delta	Paris	D18R2	Red River	48387
48047	Brooks	Pharr	D19R6	Brooks	48047
48047	Brooks	Pharr	D19R6	Cameron	48061
48047	Brooks	Pharr	D19R6	Hidalgo	48215
48047	Brooks	Pharr	D19R6	Jim Hogg	48247
48047	Brooks	Pharr	D19R6	Kenedy	48261
48047	Brooks	Pharr	D19R6	Starr	48427
48047	Brooks	Pharr	D19R6	Willacy	48489
48505	Zapata	Pharr	D19R1	Zapata	48505

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48081	Coke	San Angelo	D20R1	Coke	48081
48081	Coke	San Angelo	D20R1	Concho	48095
48081	Coke	San Angelo	D20R1	Crockett	48105
48081	Coke	San Angelo	D20R1	Edwards	48137
48081	Coke	San Angelo	D20R1	Glasscock	48173
48081	Coke	San Angelo	D20R1	Irion	48235
48081	Coke	San Angelo	D20R1	Kimble	48267
48081	Coke	San Angelo	D20R1	Menard	48327
48081	Coke	San Angelo	D20R1	Reagan	48383
48081	Coke	San Angelo	D20R1	Real	48385
48081	Coke	San Angelo	D20R1	Runnels	48399
48081	Coke	San Angelo	D20R1	Schleicher	48413
48081	Coke	San Angelo	D20R1	Sterling	48431
48081	Coke	San Angelo	D20R1	Sutton	48435
48081	Coke	San Angelo	D20R1	Tom Green	48451
48013	Atascosa	San Antonio	D21R2	Atascosa	48013
48019	Bandera	San Antonio	D21R1	Bandera	48019
48019	Bandera	San Antonio	D21R1	Frio	48163
48019	Bandera	San Antonio	D21R1	Kerr	48265
48311	McMullen	San Antonio	D21R6	McMullen	48311
48019	Bandera	San Antonio	D21R1	Medina	48325
48019	Bandera	San Antonio	D21R1	Uvalde	48463
48001	Anderson	Tyler	D22R2	Anderson	48001
48001	Anderson	Tyler	D22R2	Cherokee	48073
48001	Anderson	Tyler	D22R2	Henderson	48213
48001	Anderson	Tyler	D22R2	Van Zandt	48467
48001	Anderson	Tyler	D22R2	Wood	48499
48027	Bell	Waco	D23R2	Bell	48027
48027	Bell	Waco	D23R2	Bosque	48035
48027	Bell	Waco	D23R2	Coryell	48099
48027	Bell	Waco	D23R2	Falls	48145
48193	Hamilton	Waco	D23R1	Hamilton	48193
48027	Bell	Waco	D23R2	Hill	48217
48027	Bell	Waco	D23R2	Limestone	48293
48027	Bell	Waco	D23R2	McLennan	48309

Group ID[1]	Group Name	District Name	Composite Code[2]	County Name	County ID
48009	Archer	Wichita Falls	D24R1	Archer	48009
48009	Archer	Wichita Falls	D24R1	Baylor	48023
48009	Archer	Wichita Falls	D24R1	Clay	48077
48097	Cooke	Wichita Falls	D24R2	Cooke	48097
48009	Archer	Wichita Falls	D24R1	Montague	48337
48009	Archer	Wichita Falls	D24R1	Throckmorton	48447
48009	Archer	Wichita Falls	D24R1	Wichita	48485
48009	Archer	Wichita Falls	D24R1	Wilbarger	48487
48009	Archer	Wichita Falls	D24R1	Young	48503
48015	Austin	Yoakum	D25R2	Austin	48015
48015	Austin	Yoakum	D25R2	Calhoun	48057
48015	Austin	Yoakum	D25R2	Colorado	48089
48015	Austin	Yoakum	D25R2	De Witt	48123
48015	Austin	Yoakum	D25R2	Fayette	48149
48015	Austin	Yoakum	D25R2	Gonzales	48177
48015	Austin	Yoakum	D25R2	Jackson	48239
48015	Austin	Yoakum	D25R2	Lavaca	48285
48015	Austin	Yoakum	D25R2	Matagorda	48321
48015	Austin	Yoakum	D25R2	Victoria	48469
48015	Austin	Yoakum	D25R2	Wharton	48481

[1] The 34 final adjusted rates Group IDs are the five character county FIPS codes of the county representing each group (essentially the first county in each group, alphanumerically).

[2] The first three characters of the composite code (fourth column) identify the associated TxDOT district (i.e., D1 through D25). The last two characters in the composite code show the associated fuels region (R1 through R6, consistent with the six MOVES fuel regions for Texas). Of the 34 county groups for the 214 counties analysis, 14 represent the TxLED counties (i.e., all the fuel region R2 county groups), which were adjusted for TxLED effects.

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APPENDIX B: EMISSIONS ESTIMATION UTILITIES FOR MOVES-BASED EMISSIONS INVENTORIES

TTI UTILITIES FOR MOVES2014A-BASED EMISSIONS INVENTORIES

The following is a summary of utilities developed by TTI (written in the Visual Basic programming language) for producing detailed, link-based, hourly, and 24-hour emissions estimates for on-road mobile sources using the latest version of EPA's MOVES model (MOVES2014a). These utilities produce inputs used with the MOVES model, make special adjustments to the emissions factors (when required), and multiply them with travel model link-based or Highway Performance Monitoring System (HPMS)-based (virtual link) activity estimates to produce emissions at user-specified temporal and spatial scales.

The main utilities for calculating hourly and 24-hour emissions using MOVES are TRANSVMT, VirtualLinkVMT, VehPopulationBuild, OffNetActCalc, MOVESactivityInputBuild, MOVESfleetInputBuild, RatesCalc, RatesAdj, and EmsCalc. The TRANSVMT and VirtualLinkVMT prepare the link VMT and speeds activity input. The VehPopulationBuild utility builds the vehicle population used to calculate the off-network activity. The OffNetActCalc utility builds the SHP, starts, SHI, and APU hours required to estimate emissions using the rate-per-activity emissions rates produced by the RatesCalc or RatesAdj utilities. The MOVESactivityInputBuild and MOVESfleetInputBuild utilities build inputs used in MOVES. The RatesCalc utility assembles the emissions rates from the MOVES output in terms of rate-per-activity, including rate-per-SHP for the evaporative emissions processes. The RatesAdj utility makes special adjustments to the emissions rates when required. The EmsCalc utility calculates emissions by hourly time periods, producing a tab-delimited summary file (including 24-hour totals), hourly link emissions output files (optional), and an optional tab-delimited summary file by MOVES SCC.

A process flow diagram follows the utility descriptions.

TRANSVMT

The TRANSVMT utility post-processes TDMs to produce hourly, on-road vehicle, seasonal and day-of-week specific, directional link VMT, and speed estimates. The TRANSVMT utility processes a TDM traffic assignment by multiplying the link volumes by the appropriate HPMS, seasonal, or other VMT factors. Hourly factors are then used to distribute the link VMT to each hour in the day. A speed model is used to estimate the operational time-of-day link speeds for each direction. Since intrazonal links are not included in the TDM, special intrazonal links are created and the VMT and speeds for these special links are estimated using the intrazonal trips from the trip matrix and the zonal radii. The link VMT and speeds produced by TRANSVMT are subsequently input to the EmsCalc utility for applying the MOVES-based emissions factors (as well as with other utilities to develop off-network activity estimates).

VirtualLinkVMT

The VirtualLinkVMT utility post-processes county HPMS AADT VMT, centerline miles, and lane miles by functional classification and area type (from TxDOT's annual RIFCREC report) to produce hourly, on-road vehicle fleet, seasonal and day-of-week specific actual or projected VMT, and directional operational speed estimates. These estimated VMT and speeds are produced for up to 42 directional HPMS functional classification/area type combinations, or "links." The VirtualLinkVMT utility was developed for use in areas that do not have TDM networks, as well as for inventory applications for which network link-based detail is not required. The main inputs to VirtualLinkVMT are:

- County HPMS datasets, which include AADT VMT, centerline miles, and lane miles by HPMS area type and functional class;
- County-level VMT control totals;
- Hourly VMT distributions; and
- Speed model inputs to include volume/delay equation parameters adapted for HPMS, and free-flow speeds and lane capacities by HPMS functional classification and area type.

VirtualLinkVMT initially scales the county HPMS AADT VMT at the link level to the appropriate VMT (e.g., uses a county-level VMT control total-to-AADT ratio to produce seasonal, day-of-week specific VMT). Hourly factors and directional split factors are applied to the adjusted VMT on each link to estimate the hourly, directional VMT (and volumes) by HPMS link. Congested speed models, each for the high- and low-capacity links, are used to estimate the hourly operational speeds by direction for each link. The operational speeds are based on v/c-derived directional delay (minutes/mile) applied to the estimated free-flow speeds for each link. The virtual link VMT and speeds produced using the VirtualLinkVMT utility are an input to the emissions calculation utility, EmsCalc (as well as with other utilities to develop off-network activity estimates).

VehPopulationBuild

The VehPopulationBuild utility builds the sourcetypeyear data files in a format consistent with the MOVES input database table and the SUT/fuel type population input file (can be used with the EmsCalc utility to estimate emissions or the OffNetActCalc utility to estimate starts and SHP) using the VMT mix and the TxDMV registration datasets. The TxDMV registration datasets are three sets of registration data (an age registration data file, a gas trucks registration data file, and a diesel trucks registration data file) that list 31 years of registration data. The primary inputs to this utility are:

- County ID file, which specifies the county for which the output will be calculated;
- Age registration data file, which lists 31 years of registration data for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, Total Trucks <=8500, Gas Trucks >8500, Diesel Trucks >8500, Total Trucks >8500, and Total All Trucks vehicle categories;
- Gas trucks registration data file, which lists 31 years of registration data for the Gas >8500, Gas >10000, Gas >14000, Gas >16000, Gas >19500, Gas >26000, Gas >33000, Gas >60000, and Gas Totals gas truck categories;
- Diesel trucks registration data file, which lists 31 years of registration data for the Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000, Diesel >19500, Diesel >26000, Diesel >33000, Diesel >60000, and Diesel Totals diesel truck categories;
- VMT mix by TxDOT district, MOVES SUT, and MOVES fuel type;
- TxDOT district name file, which specifies the VMT mix TxDOT district;

- MOVES default database;
- Population factor file (optional); and
- Year ID file (optional, only used if population factors are used), which specifies the year for calculating the output.

For the desired county (from the county ID file), the age registration data (for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, and Total Trucks <=8500 vehicle categories) are saved in an age registration data array. The gas truck registration data (for the Gas >8500, Gas >10000, Gas >14000, Gas >16000, Gas >19500, Gas >26000, Gas >33000, and Gas >60000 gas truck categories) are saved in the gas truck section of the diesel/gas registration data array. The diesel truck registration data (for the Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000, Diesel >19500, Diesel >26000, Diesel >33000, and Diesel >60000 diesel truck categories) are saved in the diesel truck section of the diesel/gas registration data array. The age registration data array and the diesel/gas registration data array are combined to form the registration category data array (seven categories for 31 years of data and the total) using the combinations in the following Registration Categories table.

Registration Categories.

Registration Category	Vehicle Category	Data Location
1	Passenger Vehicle	Age registration data array
2	Motorcycles	
3	Total Trucks <=8500	
4	Diesel >8500, Diesel >10000, Diesel >14000, Diesel >16000	Diesel/gas registration data array
5	Diesel >19500, Diesel >26000, Diesel >33000, Diesel >60000	
6	Gas >8500, Gas >10000, Gas >14000, Gas >16000	
7	Gas >19500, Gas >26000, Gas >33000, Gas >60000	

The registration category data array is used to fill the SUT population array (by SUT and fuel type) for all vehicles except long-haul trucks. Each SUT/fuel type combination is assigned the total registrations from one or more of the registration categories in the registration category data array. The SUT/Registration Category Correlation table shows the SUTs and their associated registration category in the registration category data array.

SUT/Registration Category Correlation.

SUT	Registration Category
11	2
21	1
31, 32	3
41, 42, 43, 51, 52, 54	4 + 6
61	5 + 7

SUT population factors are calculated by SUT/fuel type using the data from the VMT mix input for all SUTs except motorcycles (SUT 11) and the long-haul trucks (SUTs 53 and 62) and saved in the SUT population factors array. For SUT 21, the fuel type VMT mix is divided by the total VMT mix for SUT 21. For SUT 31, the fuel type VMT mix is divided by the total VMT mix for SUTs 31 and 32. The same process applies to SUT 32. For SUT 41, the fuel type VMT mix is divided by the total VMT mix for SUTs 41, 42, 43, 51, 52, and 54. The same process applies to SUTs 42, 43, 51, 52, and 54. For SUT 61, the fuel type VMT mix is divided by the total VMT mix for SUT 61.

For SUT 11, the SUT population factor for fuel type 1 (gasoline) is set 1 with all other factors set to 0. For SUT 53, the SUT population factors by fuel type are calculated by dividing the fuel type VMT mix for SUT 53 by the fuel type VMT mix for SUT 52. For SUT 62, the SUT population factors by fuel type are calculated by dividing the fuel type VMT mix for SUT 62 by the fuel type VMT mix for SUT 61, therefore creating a ratio of long-haul and short-haul trucks.

The SUT population factors and the population factor (if desired) are applied to the SUT population array for all SUTs except SUT 53 and 62. For SUT 53, the SUT population factors for SUT 53 are applied to the SUT population array for SUT 52. For SUT 62, the SUT population factors for SUT 62 are applied to the SUT population array for SUT 61.

Using the appropriate MySQL code, a new sourcetypeyear database table is created. The data in the SUT population array is aggregated by fuel type and used to fill the sourcetypeyear database table, along with the yearID, salesGrowthFactor, and migrationrate. For the yearID, the year of the registration data is used, unless a population factor is used, in which case the year from the year ID input is used. The salesGrowthFactor and migrationrate for each SUT is set 1. A text format of this database table is written by the utility as well. The SUT/fuel type population input file is written using the SUT population array.

OffNetActCalc

The OffNetActCalc calculates the analysis scenario (i.e., year, season, day-type) SHP, starts, SHI, and APU hours by hour, SUT, and fuel type used to estimate emissions using the EmsCalc utility. The SHI and APU hours are only calculated for SUT 62, fuel type 2 (CLhT_Diesel). The SHP is calculated using either the TDM or the virtual link-based link VMT and speeds (same as used in the distance-based emissions estimation), the 24-hour or time period VMT mix (by roadway type and SUT/fuel type), and the SUT/fuel type population (from the VehiclePopulationBuild utility). The starts activity is calculated using the SUT/fuel type population and the starts per vehicle (typically the MOVES default). The SHI and APU hours are a function of hotelling hours. This utility has two options for calculating the hotelling hours. Using the first option, the analysis scenario 24-hour hotelling hours is calculated using a user-supplied extended idle factor applied to the SHO. However, this method of estimating the hotelling hours as a direct function of the SHO does not consider the availability of locations where extended idling may occur. The second option (and suggested method) uses base data (24-hour hotelling, link VMT and speeds, and VMT mix), the analysis scenario data used to calculate the SHP, and the analysis scenario SHP to calculate the analysis scenario 24-hour hotelling hours.

For the analysis scenario first hourly VMT and speeds input, the utility applies the appropriate VMT mix (either the 24-hour VMT mix or the appropriate time period VMT mix as assigned by the user) to each link that has the desired county code; thus distributing the link VMT to each SUT/fuel type, which is added to the hourly SUT/fuel type VMT. The link VMT by SUT/fuel type is divided by the link speed to calculate the link VHT (or SHO) by SUT/fuel type, which is added to the SUT fuel/type VHT. This calculation process is repeated for each analysis scenario VMT and speeds input; therefore producing the analysis scenario hourly values for VMT by SUT/fuel type and for VHT by SUT/fuel type.

The analysis scenario hourly SUT/fuel type speed, total hours (or source hours), and SHP are then calculated. For each hour and SUT/fuel type, the hourly SUT/fuel type VMT is divided by the hourly SUT/fuel type VHT to calculate the hourly SUT/fuel type speed. The hourly SUT/fuel type total hours are set equal to the SUT/fuel type population. The hourly SUT/fuel type SHP is calculated by subtracting the hourly SUT/fuel type VHT (or SHO) from the hourly SUT/fuel type total hours. If the calculated SHP is negative (i.e., SHO is greater than the total hours), the SHP is set to 0.

To calculate the analysis scenario 24-hour hotelling hours under option 1 (as a direct function of SHO), the utility multiplies the CLhT_Diesel analysis scenario 24-hour SHO by the user-supplied extended idle factor, which represents the amount of extended idle time that must occur per SHO. For option 2 (as a function of base hotelling data), the utility calculates the base 24-hour CLhT_Diesel VMT using the base VMT and speeds inputs and the base VMT mix with the same procedure used in the analysis scenario SHP calculations. The 24-hour analysis scenario CLhT_Diesel VMT is then divided by the 24-hour base CLhT_Diesel VMT to create a scaling factor, which is then applied to the base 24-hour hotelling hours to calculate the analysis scenario 24-hour hotelling hours.

The utility then calculates the analysis scenario hourly hotelling hours. The analysis scenario hourly CLhT_Diesel SHO (from the SHP calculation process) is converted to hourly VHT fractions. The hourly hotelling fractions are calculated as the inverse of the hourly VHT fractions. The hourly hotelling fractions are then applied to the analysis scenario 24-hour hotelling hours to calculate the hourly hotelling hours. For each hour, the hourly hotelling hours are then compared to the hourly CLhT_Diesel SHP. For those hours where the hotelling hours are greater than the SHP, hotelling hours are set to the SHP for that hour.

The utility then calculates the SHI fraction and the APU fraction using the source type age distribution (same distribution used in the MOVES runs), the relative MARs, and the hotelling activity distribution. Travel fractions for SUT 62 (CLhT) by ageID (0 through 30) are calculated by multiplying the age distribution by the appropriate relative MAR, which is then converted into a distribution by dividing the individual travel fraction (ageID 0 through 30) by the sum of the travel fractions. These travel fractions are then applied to the appropriate operating mode fractions from the hotelling activity distribution (operating mode 200) and summed to calculate the SHI fraction. Using a similar process, the APU fraction is calculated using the operating mode fractions for operating mode 201. For each hour the analysis scenario hotelling hours are multiplied by the SHI fraction to calculate the analysis scenario SHI activity and by the APU fraction to calculate the analysis scenario APU hours.

MOVESactivityInputBuild

The MOVESactivityInputBuild utility builds the roadtypedistribution, hourvmtfraction, avgspeeddistribution, roadtype, hpmsvtypeday, sourcetypedayvmt, year, state, zone, zoneroadtype, monthvmtfraction, and dayvmtfraction data files in a format consistent with the MOVES input database tables using the link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility, the VMT mix, and the MOVES defaults. The utility additionally has the option of building the sourcetypeage (adjusted to reflect the 24-hour VMT mix), starts, and hotellinghours data files in a format consistent with the MVOES input database tables using the output from the OffNetActCalc utility, along with inputs from the MOVES runs and the MOVES defaults. The primary inputs to this utility are:

- Link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility;
- County ID file which specifies the county number in the link-based hourly VMT and speeds for which the output will be calculated;
- VMT roadway type designations, which lists associations of the link roadway types/area type combination to the VMT mix, emissions rate, and MOVES roadway types (same as used with the EmsCalc utility);
- 24-hour or time period VMT mix by roadway type, MOVES source type, and MOVES fuel type (same as used with the EmsCalc utility);
- Day ID, which specifies the MOVES day ID for calculating the output;
- Year ID, which specifies the year for calculating the output;
- Link/Ramp designations, which designates each link roadway type/area type combination to either ramp or non-ramp;
- MOVES default database;
- Month ID, which specifies the month for calculating the output;
- sourcetypeyear, SUT age, and sourcetypeage inputs from the MOVES runs (optional, only if sourcetypeage table output is to be created);
- Starts output from the OffNetActCalc utility (optional, only if starts table output is to be created); and

- Hotelling, extended idle, and APU hours output from the OffNetActCalc utility (optional, only if hotelling table output is to be created).

For each link in the link-based hourly VMT and speeds in which the county number matches the desired county ID, the link VMT is saved in a VMT summary array based on hour, link functional class, and link area type. The link VHT (link VMT/link speed) is saved in a VHT summary array based on hour, link functional class, link area type, and MOVES average speed bin ID (determined using the MOVES average speed bins and the link speed). The link VHT is additionally saved in a road type VHT array based on link functional class and link area type, and, if the link is specified as ramp by the link/ramp designations specified by the user, the VHT is additionally saved in the ramp segment of the road type VHT array.

A MOVES roadway type array by MOVES roadway type (roadTypeID codes 2 through 5) is additionally created using the data in the VMT summary array and VMT roadway type designations. For the link road types designated a MOVES road type of 6 or 8, the VMT is added to MOVES road type 2 in the MOVES roadway type array. For the link road types designated a MOVES road type of 7 or 9, the VMT is added to MOVES road type 4 in the MOVES roadway type array. An hourly VMT array (by MOVES SUT, MOVES roadway type, and hour) is formed using the data in the VMT summary array, the VMT roadway type designations, and the VMT mix. If the time period VMT mix is used, each hour is assigned a time period by the user. Otherwise, the same 24-hour VMT mix is used for all hours. An average speed distribution array (by MOVES SUT, MOVES roadway type, hour, and MOVES speed bin) is created using the VHT summary array and the VMT mix. Using the appropriate MySQL code, the MOVES roadtypedistribution, hourvmtfraction, and avgspeeddistribution default values are extracted and saved for later use.

The VMT in the MOVES roadway type array is used to produce the roadway type distribution array by MOVES SUT and MOVES roadway type. This VMT is converted to a distribution by MOVES SUT (i.e., the total for a SUT over the five MOVES roadway types should equal 1), with the distribution value for MOVES roadway type 0 (Off-Network) equal to 0. The utility writes the tab-delimited roadtypedistribution table output (optional).

The VMT in the hourly VMT array is added to the hourly VMT fraction array (by SUT, MOVES roadway type, and hour) and for those roadway types where the VMT for all hours is greater than 0, this VMT is converted to an hourly distribution. For those roadway types where the VMT is equal to 0, a value of 1 is placed in the first hour, followed by 0 in the remaining hours. The utility writes the tab-delimited hourvmtfraction table output (optional). For those SUTs where the VMT mix is greater than 0, the hourly VMT fraction array is used. Otherwise, the MOVES hourvmtfraction default values are used.

The VHT in the average speed distribution array is converted to a distribution by SUT, MOVES roadway type, hour/day (combination of hour and the day ID specified by the user), and MOVES average speed bin. The utility writes the tab-delimited avgspeeddistribution table output (optional). For those SUTs where the VMT mix is greater than 0, the average speed distribution array is used. Otherwise, the MOVES avgspeeddistribution default values are used.

The VHT in the road type VHT array is converted to a proportion of ramp VHT by dividing the ramp segment of the road type VHT array by the total VHT for the road type in the road type VHT. The utility writes the tab-delimited roadtype table output (optional). If the ramp fraction for roadTypeID 2 is greater than 0, then roadTypeID 6 (with rampFraction equal to 0) and roadTypeID 8 (with rampFraction equal to 1) are additionally added to the roadtype database table. If the ramp fraction for roadTypeID 4 is greater than 0, then roadTypeID 7 (with rampFraction equal to 0) and roadTypeID 9 (with rampFraction equal to 1) are additionally added to the roadtype database table.

The VMT in the hourly VMT array is aggregated to create the 24-hour HPMS vehicle type VMT array. Each SUT is assigned an HPMS vehicle type (SUT 11 is HPMS vehicle type 10; SUTs 21, 31 and 32 are HPMS vehicle type 25; SUTs 41, 42, and 43 are HPMS vehicle type 40; SUTs 51, 52, 53, and 54 are HPMS vehicle type 50; and SUTs 61 and 62 are HPMS vehicle type 60). The utility writes the tab-delimited hpmsvtypeday table output (optional).

The VMT in the hourly VMT array is additionally aggregated by SUT to create the 24-hour SUT VMT array. Using this VMT data, the utility writes the tab-delimited sourcetypedayvmt output table (optional) in a format consistent with the MOVES input.

Using the appropriate MySQL code, the fuel year ID is extracted from the MOVES default year database table for the user-supplied year ID. The tab-delimited year table output is written (optional) using the user-supplied year ID and the extracted fuel year ID. The “isbaseYear” data is written as well (automatically set to “Y”).

The utility additionally produces two tab-delimited summary output files. A tab-delimited VMT summary is output by hour, link road type, and link area type for the user-specified county. A tab-delimited VHT summary is output by hour, link road type, link area type, and MOVES average speed bin for the user-specified county.

The utility creates five other tab-delimited outputs (state, zone, zoneroadtype, monthvmtfraction, and dayvmtfraction tables) using the user-supplied inputs. For the state table (optional), the utility extracts the data from the MOVES default state database table where the state ID is 48 and writes this data to the tab-delimited state table output. For the zone table (optional), the utility extracts the data from the MOVES default zone data for the county ID greater than 48000 and county ID less than 49000 and writes this data to the tab-delimited zone table output with the start allocation factors, idle allocation factors, and SHP allocation factors replaced with values of 1.

For the zoneroadtype table (optional), the utility extracts the MOVES default zoneroadtype data where the zone ID is greater than 480000 and zone ID is less than 490000 and writes this data to the tab-delimited zoneroadtype table output, with the SHO allocation factors replaced with values of 1. For the monthvmtfraction table (optional), the utility extracts the data from the MOVES default monthvmtfraction table and writes the data to the tab-delimited monthvmtfraction table output with the month VMT fraction set to 1 for the user-supplied month ID and 0 for all other months. For the dayvmtfraction table (optional), the utility extracts the data from the MOVES default dayvmtfraction table and writes this data to the tab-delimited dayvmtfraction table output with the day VMT fraction is set to 1 for the user-supplied day ID and 0 for all other months.

For the sourcetypeage table output (optional, additionally needed if the hotelling hours table output is to be created), the utility calculates the adjusted relative MARs by multiplying the input relative MAR (categorized by SUT and age from the sourcetypeage input) by the SUT-specific relative MAR adjustment factors (one factor per SUT applied across all age categories). These adjustment factors are calculated using inventory SUT VMT fractions within each HPMS vehicle type and the sum of the SUT-specific normalized travel fractions within each HPMS vehicle type. The inventory SUT VMT fractions within each HPMS vehicle type are calculated by dividing the 24-hour SUT VMT by the 24-hour HPMS vehicle type VMT for the respective SUT.

For the sum of the SUT-specific normalized travel fractions within each HPMS vehicle type, the utility uses the same calculation procedures used by MOVES to calculate the normalized travel fractions. The SUT vehicle population is distributed to each age category using the SUT age distribution input. Using the sum of the vehicle population by HPMS vehicle type, the SUT population fraction for each age category within each HPMS vehicle type is calculated by dividing the SUT vehicle population by age by the sum of the vehicle population by HPMS vehicle type. The utility then calculates the initial travel fractions (by SUT and age) by multiplying the SUT population fraction for each age category within each HPMS vehicle type by the relative MAR input.

These initial travel fractions are then normalized within each HPMS vehicle type to produce the SUT and age-specific normalized travel fractions within each HPMS vehicle type. The utility then calculates the SUT-specific relative MAR adjustment factors by dividing the inventory SUT VMT fractions within each HPMS vehicle type by the sum of the SUT and age-specific normalized travel fractions (i.e., aggregated across the age category for each SUT); resulting in one SUT-specific relative MAR adjustment factor for each SUT.

For the starts table output (optional), the utility aggregates the SUT/fuel type hourly starts input (output from the OffNetActCalc utility) by SUT and multiplies the SUT hourly starts by the SUT age distribution (by SUT) to distribute the hourly SUT starts to each age category. The SUT hourly starts by age are written to the starts table output file, along with the user-supplied monthID, yearID, dayID (used to form the output hourDayID), and zoneID (set using the user-supplied county FIPS code.

For the hotelling hours table output (optional), the utility uses travel fractions specific to SUT 62 to distribute the hourly hotelling hours input (output from the OffNetActCalc utility) to each age category. These travel fractions are calculated by multiplying the SUT 62 age distribution by the calculated relative MARs (MOVES defaults adjusted so to reflect the emissions inventory 24-hour VMT mix) for each age category and dividing by the sum of the product for all the age categories. These travel fractions are multiplied by the hourly hotelling hours input and written to the hotelling hours table output, along with the user-supplied dayID (used to form the output hourDayID), monthID, yearID, and zoneID (set using the user-supplied county FIPS code).

MOVESfleetInputBuild

The MOVESfleetInputBuild utility builds the sourcetypeagedistribution database table and fuel/engine fraction inputs to MOVES using the TxDOT registration datasets and the MOVES default database tables. The TxDOT registration datasets are three sets of registration data (an age registration data file, a gas trucks registration data file, and a diesel trucks registration data file) that list 31 years of registration data. The primary inputs to this utility are:

- Age registration data file, which lists 31 years of registration data for the Passenger Vehicles, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, Total Trucks <=8500, Gas Trucks >8500, Diesel Trucks >8500, Total Trucks >8500, and Total All Trucks vehicle categories;
- Gas trucks registration data file, which lists 31 years of registration data for the Gas > 8500, Gas > 10000, Gas > 14000, Gas > 16000, Gas > 19500, Gas > 26000, Gas > 33000, Gas > 60000, and Gas Totals gas truck categories;
- Diesel trucks registration data file, which lists 31 years of registration data for the Diesel > 8500, Diesel > 10000, Diesel > 14000, Diesel > 16000, Diesel > 19500, Diesel > 26000, Diesel > 33000, Diesel > 60000, and Diesel Totals diesel truck categories;
- SUT data sources input, which specifies the data source for each SUT to use when building the sourcetypeagedistribution database table;
- Fuel/engine fractions data sources input, which specifies the data source for each SUT to use when building the fuel/engine fractions;
- Default sourcetypeage distribution input;
- MOVES default database; and
- Year ID file (optional, only if year is not the registration data year as in a future year analysis), which specifies the year for calculating the output.

The SUT data sources input lists the data source for each SUT, either a single county, multiple counties, state, or MOVES default. As this input is processed, the utility maintains a list of the input sources. The same applies to the fuel/engine fractions, except data source inputs are only valid for source types 52, 53, and 61 (other are not valid due to data limitations and source type 62 are all considered diesel).

For each county (or state total) in the list of the input sources, the age registration data (for the Passenger Vehicle, Motorcycles, Trucks <=6000, Trucks >6000 <=8500, and Total Trucks <=8500 vehicle categories) are saved in an age registration data array. The gas truck registration data (for the Gas > 8500, Gas > 10000, Gas > 14000, Gas > 16000, Gas > 19500, Gas > 26000, Gas > 33000, and Gas > 60000 gas truck categories) are saved in the gas truck section of the diesel/gas registration data array. The diesel truck registration data (for the Diesel > 8500, Diesel > 10000, Diesel > 14000, Diesel > 16000, Diesel > 19500, Diesel > 26000, Diesel > 33000, and Diesel > 60000 diesel truck categories) are saved in the diesel truck section of the diesel/gas registration data array.

The age registration data array and the diesel/gas registration data array are combined to create the registration category data array (a total of seven categories for 31 years of data and the total) using the combinations in the Registration Categories table. The county is compared to the data sources for each SUT in the SUT data sources input. If the county is found for a given source type, then the 31 years of registration data from the source type's corresponding category in the registration category data array are added to the SUT age distribution array. See the SUTs/Registration Categories Correlation for SUT Age Distribution shows table for the source types and their corresponding registration categories.

SUTs/Registration Categories Correlation for SUT Age Distribution.

SUT	Registration Category
11	2
21	1
31, 32	3
52, 53	4
61, 62	5

A similar process is followed for the fuel/engine fractions array. However, only SUTs 52, 53, 61, and 62 are processed due to data limitations. The registration data are saved in the fuel/engine fractions array based on fuel type. The table SUTs/Registration Categories Correlation for Fuel/Engine Fractions shows the SUTs and their corresponding registration categories.

SUTs/Registration Categories Correlation for Fuel/Engine Fractions.

SUT	Fuel Type	Registration Category
52, 53	Diesel	4
	Gas	6
61	Diesel	5
	Gas	7
62	Diesel	5 + 7
	Gas	None – all are assumed diesel

After processing all of the counties, the data from the default sourcetypeage distribution input are processed and the data for the registration data year are saved in the default age distribution array. For each source type in which the registration data are to be used for the age distribution, the 31 years of registration data in the SUT age distribution array are converted to a distribution by dividing the source type yearly registration data by the source type total registration data. For each source type in which the defaults are to be used, the defaults values from the default age distribution array are copied to the SUT age distribution array.

The MOVES default fuel/engine fractions are extracted from the MOVES default database (using the appropriate code for MySQL) and saved in the default fuel/engine fractions array. For source types 52, 53, and 61, the source type yearly registration data in the fuel/engine fractions array are converted to fuel/engine fractions by dividing the yearly source type diesel registration data by the sum of the yearly source type diesel registration data and the yearly source type gas registration data.

If the year ID input is used, then these fuel/engine fractions are adjusted to match the year from the year ID input. If the year from the year ID input is greater than the registration data year, then the first fuel/engine fraction is extended to match the year from the year ID input and the appropriate number of years is dropped from the end of the fuel/engine fractions to maintain the appropriate distribution. If the year from the year ID input is less than the registration data year, then the last fuel/engine fraction is extended to match the year from the year ID input and the appropriate number of years is dropped from the beginning of the fuel/engine fractions to maintain the appropriate distribution. For source type 62, all of the fuel/engine fractions in the fuel/engine fractions array are set to a value of 1.

Using the appropriate MySQL code, a new sourcetypeagedistribution database table is created and the data from the SUT age distribution array, along with the year ID (either from the registration data or the year ID input), are used to fill the new database table. A text format of this database table may be written as well. Using the appropriate MySQL code, a new AVFTfuelengfraction database table is created and the data from the fuel/engine fractions array are used to fill the new database table for SUTs 52, 53, 61, and 62. For all other SUTs, the default fuel/engine fraction array data for the appropriate year (either the registration data year or the year ID input) are used to fill the new database table. A text format of this database table may be written as well.

RatesCalc

The RatesCalc utility calculates emissions rates in terms of rate/SHP for the evaporative emissions processes using the data in the CDB used in the MOVES emissions rates run and the MOVES default database. The utility additionally creates copies of the rateperdistance, rateperhour, and rateperstartemissions rate tables to include the units for each pollutant. If not specified, emissions rates are assembled for each pollutant and process combination (excluding total energy and the refueling emissions processes) in the MOVES emissions rate tables. The utility additionally uses the movesrun database table, along with a pollutant energy or mass look-up table (mass, TEQ, or gmole), to determine the units of the emissions rates, which are added to the emissions rate tables allowing the user to specify any of the units available in MOVES for the MOVES emissions rate run. The type of activity used for the emissions rate calculation is determined by the process, shown in the MOVES2014a Emissions Process and Corresponding Activity for Rate-per-Activity Emissions Rates table.

MOVES2014a Emissions Process and Corresponding Activity for Rate-per-Activity Emissions Rates.

MOVES2014a Emissions Process	Activity	Emissions Rate Units
Running Exhaust	Miles Traveled	Rate/Mile
Crankcase Running Exhaust	Miles Traveled	Rate/Mile
Start Exhaust	Starts	Rate/Start
Crankcase Start Exhaust	Starts	Rate/Start
Extended Idle Exhaust	Extended Idle Hours	Rate/Extended Idle Hour
Crankcase Extended Idle Exhaust	Extended Idle Hours	Rate/Extended Idle Hour
Auxiliary Power Exhaust	APU Hours	Rate/APU Hour
Evaporative Permeation	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Evaporative Fuel Vapor Venting	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Evaporative Fuel Leaks	Miles Traveled Source Hours Parked	Rate/Mile Rate/SHP
Brake Wear	Miles Traveled	Rate/Mile
Tire Wear	Miles Traveled	Rate/Mile

For the rateperdistance (rate/mile emissions rates) emissions rate table, the utility creates a copy of the emissions rates in the specified output database with the table name ttirateperdistance. If specific pollutants are specified, only the emissions rates for those pollutants are copied to the ttirateperdistance table. Otherwise, the entire rateperdistance table is copied to the ttirateperdistance table. The utility additionally adds a “Units_Per_Activity” field to the ttirateperdistance table and fills that field based on the pollutants energy or mass designation (mass, TEQ, or gmole). For those pollutants designated as mass, the mass units from the movesrun table are added to the “Units_Per_Activity” field. For those pollutants designated as gmole, the mass units from the movesrun table, along with the text “-mole” (i.e., pound-mole or gram-mole) are added to the “Units_Per_Activity” field. For those pollutants designated as TEQ, the text “TEQ” is added to the “Units_Per_Activity” field. No unit conversions are performed in this utility. The rateperstart and rateperhour, emissions rate tables are processed in a similar manner to produce the ttirateperstart and ttirateperhour, emissions rate tables.

For the evaporative emissions rates, the utility uses the CDB from the MOVES run and the MOVES default database to replicate the MOVES vehicle population and SHP calculation process. Using the emissions rates from the rateperprofile and ratepervehicle emissions rate tables, the utility calculates the rate-per-SHP emissions rates by multiplying the emissions rate by the appropriate vehicle population and dividing by the appropriate SHP value. These rate-per-SHP emissions rates are then saved in the ttiratepershp emissions rate table. Similar to the previous RatesCalc emissions rate tables, the "Units_Per_Activity" field is added to the ttiratepershp table and filled based on the pollutants energy or mass designation.

RatesAdj

The RatesAdj utility applies emissions rate adjustments to an emissions rate database table produced by RatesCalc utility (ttirateperdistance, ttirateperstart, ttirateperhour, or ttiratepershp) or by this utility to produce a new emissions rate database table in the same format as the input emissions rate database table. The emissions rate adjustments can be linear adjustments that are applied to all emissions rates or can be applied by SUT, fuel type, pollutant, and process (adjustments may additionally include roadway type, average speed bin, and hour). The user has the option of selecting which pollutants will be in the new emissions rate database table, along with the output units of the emissions rates. This allows the user to perform any unit conversions between mass units (i.e., pounds to grams or pound-mole to gram-mole) without providing any addition adjustment factors. Unit conversions between unit types (i.e., gram-moles to grams or TEQ to grams) are not performed internally by the utility. These types of conversions must be made using the emissions rate adjustment factors. The utility additionally has the option for combining multiple emissions rate database tables into one new emissions rate database table, if the input emissions rate database tables are in the same format.

For the first input emissions rate database table, the utility extracts the emissions rates for the specified pollutants (or all the pollutants if not specified) from the input database emissions rate table, applies the emissions rate adjustments (if necessary) and any unit conversion adjustments, and saves these adjusted emissions rates. If more than one emissions rate database table is input, then the utility performs a similar calculation process to the first input emissions rate database table for each input emissions rate database table. If pollutants are found in more than one input emissions rate database table, the adjusted emissions rates are summed to produce one emissions rate.

After processing all of the input emissions rate database tables, the utility creates a new emissions rate database table in the same format as the first input emissions rate database table and writes the adjusted emissions rates to this new emissions rate database table. Using MySQL code, the utility additionally creates a minimum and maximum emissions rate summary for each input emissions rate table and the output emissions rate table by pollutant, process, and source type/fuel type, which is written to a tab-delimited file specified by the user.

EmsCalc

The EmsCalc utility estimates the hourly link emissions for one user-specified county using the emissions factors (either from RatesCalc or RatesAdj), the 24-hour or time period VMT mix, the hourly link VMT and speeds activity estimates (either from TRANSVMT or VirtualLinkVMT), and the off-network activity (SHP, starts, and SHI). This utility produces a tab-delimited output summary (including hourly and 24-hour totals) and hourly link emissions output files (optional). The primary inputs to EmsCalc are:

- Emissions factors from RatesCalc or RatesAdj;
- Link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility. For each link, the following information is input to EmsCalc:

link start node, link end node, link county number, link roadway type number, link area type number, link VMT, and link operational speed estimate;

- 24-hour or time period VMT mix by roadway type, MOVES SUT, and MOVES fuel type;
- Off-network activity (SHP, starts, SHI, and APU hours) by hour and SUT/fuel type;
- VMT roadway type designations, which lists associations of the link roadway types/area type combination to the VMT mix, emissions rate, and MOVES roadway types;
- Pollutants input file, which specifies which pollutant/process combinations for which the emissions calculations will be performed and their respective units in the tab-delimited output;
- SCC input file (optional, only if the activity and emissions by SCC are to be created); and
- SCC pollutants input file (optional, only if the activity and emissions by SCC are to be created).

The emissions estimation can be categorized by two basic types based on the type of emissions factors: the roadway-based emissions and the off-network-based emissions. For the roadway-based emissions (ttirateperdistance emissions factors), the VMT for each link is distributed to each of the SUT/fuel type combinations listed in the VMT mix by roadway type (as designated in the VMT roadway type designations). If the time period VMT mix is input, each hour is assigned a time period by the user. Otherwise, the 24-hour VMT mix is used for all hours. For each pollutant/process combination in the pollutants input file, the emissions factors are selected based on the emissions rate roadway type (as designated in the VMT roadway type designations) and the link speed for each SUT/fuel type combinations listed in the VMT mix. For link speeds greater than 75 mph, the emissions factors for 75 mph are used. For link speeds less than 2.5 mph, the emissions factors for 2.5 mph are used. For those link speeds that fall between the 16 MOVES speeds, the emissions factors are interpolated using the emissions factor interpolation methodology in the following section. These SUT/fuel type combination-specific emissions factors are multiplied by the SUT/fuel type combination-specific VMT to estimate the mobile source emissions for that link by SUT/fuel type combination. If the activity and emissions by SCC are to be created, the activity and emissions are additionally aggregated by SCC using the SCC input file and by SCC pollutant using the SCC pollutants input file (thus allowing the user the option to combine multiple MOVES pollutants into one more aggregate pollutant).

For the off-network emissions, the ttirateperstart, ttirateperhour, and ttiratepershp emissions rates (by SUT/fuel type) are multiplied by the appropriate activity, which is determined by the emissions process (see the MOVES2014a Refueling Emissions Process and Corresponding Activity for Rate-per-Activity Emissions Rates table). If the activity and emissions by SCC are to be created, the activity and emissions are additionally aggregated by SCC using the SCC input file and by SCC pollutant using the SCC pollutants input file (thus allowing the user the option to combine multiple MOVES pollutants into one more aggregate pollutant).

The emissions estimates are output in a tab-delimited file (including all of the SUT/fuel type combinations listed in the VMT mix on a single line, separated by a tab character) for the specified county by pollutant, link roadway type, and SUT/fuel type combination for each of the specified episode time periods. A 24-hour (or total if all 24 hours are not specified) output is additionally included in the tab-delimited file. Only those pollutant/process combinations in the pollutants input file with tab-delimited output units other than "NONE" will appear in the tab-delimited output file. Prior to output, any unit conversions between mass units (i.e., pounds to grams or pound-mole to gram-mole) are performed by the utility. Unit conversions between unit types (i.e., gram-moles to grams or TEQ to grams) are not performed internally by the utility (these type of unit conversions must be done using the RatesAdj utility). This tab-delimited file additionally includes hourly and 24-hour summaries of the off-network activity and VMT, VHT, and speed by link road type. Link emissions may additionally be output by county, pollutant, process, and each SUT/fuel type combination. If specified, the tab-delimited activity and emissions by SCC output file is additionally created, which lists the activity and emissions for each SCC pollutant by SCC.

Emissions Factor Interpolation Methodology

To calculate emissions factors for link speeds that fall between two of the 16 MOVES speed bin speeds, an interpolation methodology similar to the methodology used with MOBILE6 is used. This methodology interpolates each emissions factor using a factor developed from the inverse link speed and the inverse high and low bounding speed bin speeds. The following is an example for a link speed of 41.2 mph.

The interpolated emissions factor (EF_{Interp}) is expressed as:

$$EF_{Interp} = EF_{LowSpeed} - FAC_{Interp} \times (EF_{LowSpeed} - EF_{HighSpeed})$$

Where:

$EF_{LowSpeed}$ = emissions factor (EF) corresponding to the speed below the link speed;

$EF_{HighSpeed}$ = EF corresponding to the speed above the link speed; and

$$FAC_{Interp} = \left(\frac{1}{Speed_{link}} - \frac{1}{Speed_{low}}\right) \Big/ \left(\frac{1}{Speed_{high}} - \frac{1}{Speed_{low}}\right)$$

Given that:

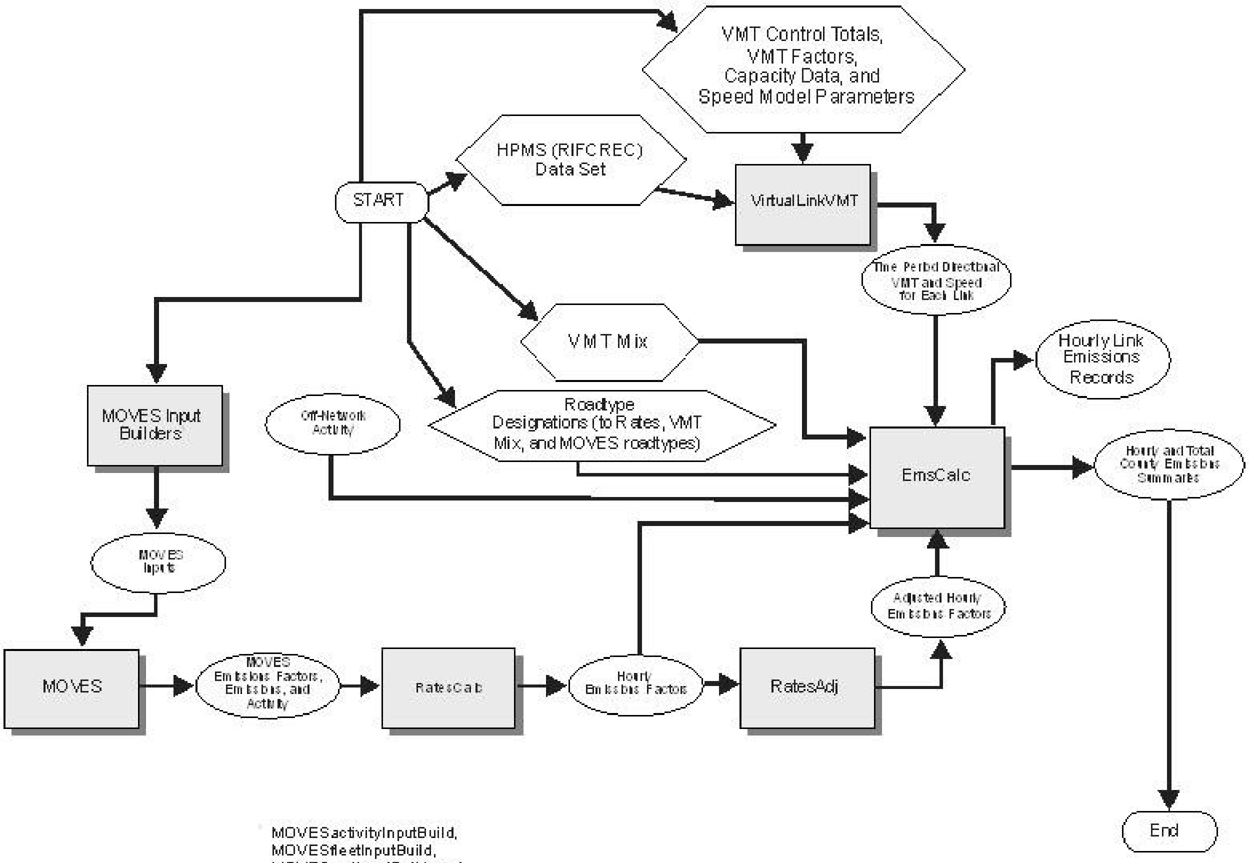
$EF_{LowSpeed}$ = 0.7413 g/mi;
$EF_{HighSpeed}$ = 0.7274 g/mi;
$Speed_{lnk}$ = 41.2 mph;
$Speed_{low}$ = 40 mph; and
$Speed_{high}$ = 45 mph.

$$FAC_{Interp} = \left(\frac{1}{41.2mph} - \frac{1}{40mph}\right) \Big/ \left(\frac{1}{45mph} - \frac{1}{40mph}\right) = \frac{-0.00073}{-0.00278} = 0.26214;$$

$$EF_{Interp} = 0.7413 \text{ g/mi} - (0.26214) \times (0.7413 \text{ g/mi} - 0.7274 \text{ g/mi});$$

$$= 0.7377 \text{ g/mi}.$$

HPMS / Virtual Link-Based Emissions Estimation Process



MOVESactivityInputBuild,
MOVESfleetInputBuild,
MOVESmetInputBuild, and
VehPopulationBuild.

VehPopulationBuild, and
OffNetActCalc.

APPENDIX C:
TXDOT DISTRICT WEEKDAY VMT MIXES BY MOVES ROAD TYPE CATEGORY

TxDOT District/TLM Counties

TxDOT District	HGB County
Atlanta	Harrison
	Upshur
Tyler	Gregg
	Rusk
	Smith

VMT Mix Year/Analysis Year Correlations

VMT Mix Year	Analysis Years
2000	1998 through 2002
2005	2003 through 2007
2010	2008 through 2012
2015	2013 through 2017
2020	2018 through 2022
2025	2023 through 2027
2030	2028 through 2032
2035	2033 through 2037
2040	2038 +

2015 Weekday VMT Mix – Atlanta TxDOT District

SUT_FT	AM Peak				Mid-Day				PM Peak				Overnight			
	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]
MC_Gas	0.00306	0.00391	0.00412	0.00447	0.00309	0.00379	0.00388	0.00427	0.00319	0.00419	0.00431	0.00467	0.00239	0.00374	0.00360	0.00452
PC_Gas	0.43445	0.55510	0.58513	0.63356	0.43851	0.53772	0.55078	0.60557	0.45201	0.59426	0.61117	0.66208	0.33840	0.53034	0.51132	0.64074
PC_Diesel	0.00279	0.00352	0.00305	0.00328	0.00263	0.00355	0.00297	0.00337	0.00254	0.00337	0.00291	0.00313	0.00170	0.00289	0.00235	0.00249
PT_Gas	0.17156	0.21656	0.18766	0.20188	0.16198	0.21854	0.18268	0.20718	0.15634	0.20698	0.17880	0.19266	0.10482	0.17789	0.14480	0.15305
PT_Diesel	0.00235	0.00297	0.00257	0.00277	0.00222	0.00300	0.00251	0.00284	0.00214	0.00284	0.00245	0.00264	0.00144	0.00244	0.00199	0.00210
LCT_Gas	0.04205	0.05308	0.04600	0.04949	0.03971	0.05357	0.04478	0.05079	0.03832	0.05074	0.04383	0.04723	0.02570	0.04361	0.03549	0.03752
LCT_Diesel	0.00162	0.00139	0.00155	0.00138	0.00156	0.00150	0.00169	0.00155	0.00130	0.00101	0.00110	0.00083	0.00106	0.00110	0.00111	0.00087
IBus_Diesel	0.00042	0.00036	0.00041	0.00036	0.00041	0.00039	0.00044	0.00041	0.00034	0.00027	0.00029	0.00022	0.00028	0.00029	0.00029	0.00023
TBus_Gas	0.03430	0.02939	0.03278	0.02937	0.03324	0.03192	0.03598	0.03298	0.02783	0.02163	0.02349	0.01771	0.02306	0.02394	0.02416	0.01889
TBus_Diesel	0.00901	0.00772	0.00861	0.00771	0.00873	0.00838	0.00945	0.00866	0.00731	0.00568	0.00617	0.00465	0.00606	0.00629	0.00635	0.00496
SBus_Gas	0.00132	0.00113	0.00126	0.00113	0.00121	0.00116	0.00130	0.00120	0.00086	0.00067	0.00073	0.00055	0.00030	0.00032	0.00032	0.00025
SBus_Diesel	0.00035	0.00030	0.00033	0.00030	0.00032	0.00030	0.00034	0.00031	0.00023	0.00018	0.00019	0.00014	0.00008	0.00008	0.00008	0.00007
RT_Gas	0.00127	0.00109	0.00121	0.00109	0.00123	0.00118	0.00133	0.00122	0.00102	0.00080	0.00086	0.00065	0.00083	0.00087	0.00087	0.00068
RT_Diesel	0.00033	0.00029	0.00032	0.00029	0.00032	0.00031	0.00035	0.00032	0.00027	0.00021	0.00023	0.00017	0.00022	0.00023	0.00023	0.00018
SUSht_Gas	0.00038	0.00072	0.00043	0.00014	0.00044	0.00039	0.00036	0.00013	0.00035	0.00016	0.00025	0.00005	0.00069	0.00025	0.00037	0.00009
SUSht_Diesel	0.00076	0.00144	0.00086	0.00027	0.00087	0.00078	0.00072	0.00026	0.00070	0.00032	0.00051	0.00009	0.00138	0.00050	0.00073	0.00017
SULht_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SULht_Diesel	0.00208	0.00395	0.00235	0.00075	0.00240	0.00215	0.00199	0.00070	0.00192	0.00088	0.00139	0.00026	0.00379	0.00138	0.00201	0.00047
MH_Gas	0.00002	0.00004	0.00002	0.00001	0.00002	0.00002	0.00002	0.00001	0.00002	0.00001	0.00001	0.00000	0.00004	0.00001	0.00002	0.00000
MH_Diesel	0.07169	0.02865	0.02970	0.01503	0.07346	0.03196	0.03857	0.01896	0.05914	0.02054	0.02357	0.01203	0.06764	0.02821	0.03655	0.01833
CShT_Gas	0.01458	0.00583	0.00604	0.00306	0.01494	0.00650	0.00784	0.00386	0.01203	0.00418	0.00479	0.00245	0.01376	0.00574	0.00743	0.00373
CShT_Diesel	0.20517	0.08200	0.08501	0.04302	0.21227	0.09235	0.11146	0.05480	0.23168	0.08048	0.09233	0.04712	0.40602	0.16935	0.21941	0.11001
CLhT_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
CLhT_Diesel	0.00044	0.00056	0.00059	0.00064	0.00044	0.00054	0.00056	0.00061	0.00046	0.00060	0.00062	0.00067	0.00034	0.00053	0.00052	0.00065

[1] RT2 - Rural Restricted Access; [2] RT3 – rural Unrestricted Access; [3] RT4 - Urban Restricted Access; [4] RT5 – Urban Unrestricted Access.

2015 Weekday VMT Mix – Tyler TxDOT District

SUT_FT	AM Peak				Mid-Day				PM Peak				Overnight			
	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]	RT2[1]	RT3[2]	RT4[3]	RT5[4]
MC_Gas	0.00060	0.00057	0.00060	0.00072	0.00058	0.00054	0.00058	0.00071	0.00064	0.00060	0.00064	0.00075	0.00052	0.00055	0.00052	0.00074
PC_Gas	0.59078	0.56004	0.59078	0.71350	0.57406	0.53521	0.57406	0.70129	0.63223	0.59679	0.63223	0.74351	0.51353	0.54598	0.51353	0.73497
PC_Diesel	0.00417	0.00395	0.00417	0.00503	0.00406	0.00378	0.00406	0.00495	0.00447	0.00421	0.00447	0.00524	0.00364	0.00386	0.00364	0.00518
PT_Gas	0.19578	0.23785	0.19578	0.18306	0.18638	0.24381	0.18638	0.19401	0.17236	0.23189	0.17236	0.17713	0.12928	0.20666	0.12928	0.15753
PT_Diesel	0.00318	0.00387	0.00318	0.00298	0.00303	0.00396	0.00303	0.00315	0.00280	0.00377	0.00280	0.00288	0.00210	0.00336	0.00210	0.00256
LCT_Gas	0.04799	0.05830	0.04799	0.04487	0.04569	0.05976	0.04569	0.04756	0.04225	0.05684	0.04225	0.04342	0.03169	0.05066	0.03169	0.03861
LCT_Diesel	0.00269	0.00326	0.00269	0.00251	0.00256	0.00334	0.00256	0.00266	0.00236	0.00318	0.00236	0.00243	0.00177	0.00284	0.00177	0.00216
IBus_Diesel	0.00028	0.00048	0.00028	0.00038	0.00024	0.00029	0.00024	0.00020	0.00017	0.00014	0.00017	0.00012	0.00023	0.00028	0.00023	0.00015
TBus_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TBus_Diesel	0.00056	0.00096	0.00056	0.00077	0.00047	0.00058	0.00047	0.00041	0.00035	0.00028	0.00035	0.00023	0.00046	0.00056	0.00046	0.00030
SBus_Gas	0.00002	0.00003	0.00002	0.00002	0.00001	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	0.00001	0.00001
SBus_Diesel	0.00154	0.00265	0.00154	0.00210	0.00130	0.00159	0.00130	0.00112	0.00095	0.00077	0.00095	0.00064	0.00126	0.00153	0.00126	0.00082
RT_Gas	0.00033	0.00058	0.00033	0.00024	0.00038	0.00061	0.00038	0.00022	0.00024	0.00043	0.00024	0.00011	0.00029	0.00048	0.00029	0.00020
RT_Diesel	0.00111	0.00193	0.00111	0.00081	0.00128	0.00206	0.00128	0.00075	0.00079	0.00143	0.00079	0.00036	0.00097	0.00161	0.00097	0.00068
SUSht_Gas	0.00662	0.01155	0.00662	0.00486	0.00775	0.01244	0.00775	0.00455	0.00480	0.00863	0.00480	0.00217	0.00613	0.01012	0.00613	0.00431
SUSht_Diesel	0.02217	0.03868	0.02217	0.01627	0.02595	0.04164	0.02595	0.01523	0.01608	0.02889	0.01608	0.00725	0.02051	0.03388	0.02051	0.01442
SULht_Gas	0.00065	0.00113	0.00065	0.00047	0.00068	0.00110	0.00068	0.00040	0.00042	0.00075	0.00042	0.00019	0.00028	0.00045	0.00028	0.00019
SULht_Diesel	0.00217	0.00378	0.00217	0.00159	0.00229	0.00367	0.00229	0.00134	0.00140	0.00251	0.00140	0.00063	0.00092	0.00152	0.00092	0.00065
MH_Gas	0.00026	0.00045	0.00026	0.00019	0.00030	0.00048	0.00030	0.00018	0.00019	0.00033	0.00019	0.00008	0.00023	0.00038	0.00023	0.00016
MH_Diesel	0.00087	0.00151	0.00087	0.00064	0.00101	0.00162	0.00101	0.00059	0.00062	0.00112	0.00062	0.00028	0.00076	0.00126	0.00076	0.00054
CShT_Gas	0.00813	0.00471	0.00813	0.00131	0.00940	0.00553	0.00940	0.00137	0.00713	0.00350	0.00713	0.00077	0.01169	0.00549	0.01169	0.00147
CShT_Diesel	0.05146	0.02978	0.05146	0.00826	0.05946	0.03497	0.05946	0.00866	0.04511	0.02217	0.04511	0.00485	0.07394	0.03471	0.07394	0.00928
CLhT_Gas	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
CLhT_Diesel	0.05864	0.03394	0.05864	0.00942	0.07312	0.04300	0.07312	0.01064	0.06463	0.03176	0.06463	0.00695	0.19979	0.09380	0.19979	0.02507

[1] RT2 - Rural Restricted Access; [2] RT3 – rural Unrestricted Access; [3] RT4 - Urban Restricted Access; [4] RT5 – Urban Unrestricted Access.

APPENDIX D:
TXDOT DISTIRCT AGGREGATE WEEKDAY VMT MIX

TxDOT District/TLM Counties

TxDOT District	HGB County
Atlanta	Harrison
	Upshur
Tyler	Gregg
	Rusk
	Smith

VMT Mix Year/Analysis Year Correlations

VMT Mix Year	Analysis Years
2000	1998 through 2002
2005	2003 through 2007
2010	2008 through 2012
2015	2013 through 2017
2020	2018 through 2022
2025	2023 through 2027
2030	2028 through 2032
2035	2033 through 2037
2040	2038 +

2015 Aggregate Weekday VMT Mix – TLM TxDOT District

SUT_FT	Atlanta	Tyler
MC_Gas	0.00053	0.00060
PC_Gas	0.52420	0.59190
PC_Diesel	0.00370	0.00417
PT_Gas	0.18583	0.21597
PT_Diesel	0.00302	0.00351
LCT_Gas	0.04555	0.05294
LCT_Diesel	0.00255	0.00296
IBus_Diesel	0.00037	0.00027
TBus_Gas	0.00000	0.00000
TBus_Diesel	0.00073	0.00053
SBus_Gas	0.00002	0.00001
SBus_Diesel	0.00201	0.00147
RT_Gas	0.00036	0.00045
RT_Diesel	0.00137	0.00150
SUSht_Gas	0.00771	0.00912
SUSht_Diesel	0.02936	0.03054
SULht_Gas	0.00088	0.00248
SULht_Diesel	0.00088	0.00248
MH_Gas	0.00028	0.00035
MH_Diesel	0.00108	0.00118
CShT_Gas	0.00817	0.00490
CShT_Diesel	0.04015	0.03102
CLhT_Gas	0.00000	0.00000
CLhT_Diesel	0.14191	0.04426

APPENDIX E:
DIRECTIONAL SPLIT ESTIMATES, CAPACITY FACTORS, AND SPEED FACTORS

TDM Area Type Codes and Descriptions

Area Type Code	Area Type Description
1	Central Business District (CBD)
2	Urban
3	Suburban
4	Rural

TDM Facility Types

Facility Type Code	Facility Type Description	Longview TDM	Tyler TDM
0	Centroid Connector	✓	✓
1	Radial IH Freeways - Mainlanes Only	✓	✓
10	Circumferential Expressways (Loops)		✓
11	Principal Arterial – Divided	✓	✓
12	Principal Arterial - Continuous Left Turn Lane	✓	✓
13	Principal Arterial – Undivided	✓	✓
14	Minor Arterial – Divided	✓	✓
15	Minor Arterial - Continuous Left Turn Lane	✓	✓
16	Minor Arterial – Undivided	✓	✓
17	Collector – Divided	✓	
18	Collector - Continuous Left Turn Lane	✓	
19	Collector – Undivided	✓	✓
20	Frontage Road	✓	
21	Ramp (Between Frontage Road and Mainlanes)	✓	✓

Longview TDM AM Peak Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	54.0	85.0	72.0	78.0
1	54.0	85.0	72.0	78.0
11	65.0	62.0	65.0	71.0
12	65.0	62.0	65.0	71.0
13	65.0	62.0	65.0	71.0
15	58.0	58.0	64.0	68.0
16	58.0	58.0	64.0	68.0
17	64.5	53.0	64.5	75.0
18	64.5	53.0	64.5	75.0
19	64.5	53.0	64.5	75.0
20	64.5	53.0	64.5	75.0
21	54.0	85.0	72.0	78.0

Longview TDM PM Peak Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	55.0	72.0	72.0	71.0
1	55.0	72.0	72.0	71.0
11	62.0	57.0	60.0	66.0
12	62.0	57.0	60.0	66.0
13	62.0	57.0	60.0	66.0
15	52.0	54.0	65.0	63.0
16	52.0	54.0	65.0	63.0
17	57.5	68.0	62.5	70.0
18	57.5	68.0	62.5	70.0
19	57.5	68.0	62.5	70.0
20	57.5	68.0	62.5	70.0
21	55.0	72.0	72.0	71.0

Longview TDM Mid-Day and Overnight Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	54.0	55.0	55.0	52.0
1	54.0	55.0	55.0	52.0
11	55.0	50.0	57.0	55.0
12	55.0	50.0	57.0	55.0
13	55.0	50.0	57.0	55.0
15	55.0	52.0	56.0	58.0
16	55.0	52.0	56.0	58.0
17	54.5	52.0	57.0	54.0
18	54.5	52.0	57.0	54.0
19	54.5	52.0	57.0	54.0
20	54.5	52.0	57.0	54.0
21	54.0	55.0	55.0	52.0

Tyler TDM AM Peak Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	54.0	85.0	72.0	78.0
1	50.0	60.0	61.0	70.0
10	50.0	60.0	61.0	70.0
11	65.0	62.0	65.0	71.0
12	65.0	62.0	65.0	71.0
13	65.0	62.0	65.0	71.0
14	58.0	58.0	64.0	68.0
15	58.0	58.0	64.0	68.0
16	58.0	58.0	64.0	68.0
19	64.5	53.0	64.5	75.0
21	50.0	60.0	61.0	70.0

Tyler TDM PM Peak Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	54.0	56.0	67.0	65.0
1	54.0	56.0	56.0	65.0
10	54.0	56.0	56.0	65.0
11	62.0	57.0	60.0	66.0
12	62.0	57.0	60.0	66.0
13	62.0	57.0	60.0	66.0
14	52.0	54.0	65.0	63.0
15	52.0	54.0	65.0	63.0
16	52.0	54.0	65.0	63.0
19	55.0	72.0	72.0	71.0
21	54.0	56.0	56.0	65.0

Tyler TDM Mid-Day and Overnight Directional Split Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	54.0	55.0	55.0	52.0
1	51.0	53.0	51.0	53.0
10	51.0	53.0	51.0	53.0
11	55.0	50.0	57.0	55.0
12	55.0	50.0	57.0	55.0
13	55.0	50.0	57.0	55.0
14	55.0	52.0	56.0	58.0
15	55.0	52.0	56.0	58.0
16	55.0	52.0	56.0	58.0
19	54.5	52.0	57.0	54.0
21	51.0	53.0	51.0	53.0

Longview TDM Hourly Capacity Factors

Facility Type Code	Area Type Code			
	1	**2**	**3**	**4**
0	0.100000	0.100000	0.100000	0.100000
1	0.090000	0.098684	0.113372	0.142857
11	0.066265	0.082278	0.108209	0.156863
12	0.066265	0.082278	0.108209	0.156863
13	0.073529	0.090909	0.120536	0.164773
15	0.075342	0.084459	0.109375	0.156250
16	0.079365	0.094262	0.115741	0.173077
17	0.056338	0.076271	0.096154	0.109375
18	0.056338	0.076271	0.096154	0.134615
19	0.067308	0.093023	0.118421	0.175926
20	0.077465	0.082237	0.104478	0.145000
21	0.056266	0.059952	0.071611	0.106383

Longview TDM Free-Flow Speed Factors

Facility Type Code	Area Type Code			
	1	**2**	**3**	**4**
0	1.000000	1.000000	1.000000	1.000000
1	1.127742	1.150307	1.116647	1.186039
11	1.242622	1.238987	1.174260	1.217083
12	1.257466	1.245847	1.262945	1.219783
13	1.210577	1.284613	1.360174	1.296864
15	1.202336	1.146460	1.186396	1.178689
16	1.209677	1.138952	1.259093	1.281394
17	1.065719	1.123596	1.147776	1.119403
18	1.069900	1.123596	1.151410	1.123315
19	1.011195	1.255380	1.179245	1.148838
20	1.404494	1.347305	1.344809	1.347709
21	1.445684	1.802885	1.972387	2.055306

Tyler TDM Hourly Capacity Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	0.100000	0.100000	0.100000	0.100000
1	0.090000	0.098684	0.113372	0.142857
10	0.091837	0.086852	0.098485	0.114943
11	0.066265	0.082278	0.108209	0.156863
12	0.066265	0.082278	0.108209	0.156863
13	0.073529	0.090909	0.120536	0.164773
14	0.075342	0.084459	0.109375	0.156250
15	0.075342	0.084459	0.109375	0.156250
16	0.079365	0.094262	0.115741	0.173077
19	0.067308	0.093023	0.118421	0.175926
21	0.056266	0.059952	0.071611	0.106383

Tyler TDM Free-Flow Speed Factors

Facility Type Code	Area Type Code			
	1	2	3	4
0	1.000000	1.000000	1.000000	1.000000
1	1.170213	1.200000	1.250000	1.250000
10	1.500000	1.351351	1.279070	1.250000
11	1.538462	1.323529	1.219512	1.145833
12	1.538462	1.363636	1.282051	1.195652
13	1.583333	1.406250	1.315789	1.222222
14	1.458333	1.250000	1.216216	1.086957
15	1.458333	1.250000	1.250000	1.086957
16	1.375000	1.290323	1.250000	1.136364
19	1.166667	1.296296	1.212121	1.097561
21	1.346154	1.730769	1.851852	1.964286

APPENDIX F:
VEHICLE POPULATION ESTIMATES AND 24-HOUR SHP, STARTS, HOTELLING HOURS, SHI, AND APU HOURS SUMMARIES

2017 Vehicle Population Estimates

SUT_FT	Gregg	Harrison	Rusk	Smith	Upshur
MC_Gas	2,325	1,544	916	4,385	1,114
PC_Gas	64,171	29,892	19,630	122,093	17,839
PC_Diesel	453	211	139	861	126
PT_Gas	25,934	15,241	10,193	44,405	9,518
PT_Diesel	421	248	166	722	155
LCT_Gas	6,357	3,736	2,499	10,885	2,333
LCT_Diesel	355	209	140	609	131
IBus_Diesel	27	18	9	29	11
TBus_Gas	0	0	0	0	0
TBus_Diesel	52	35	18	57	22
SBus_Gas	1	1	0	1	1
SBus_Diesel	145	96	49	159	60
RT_Gas	45	17	15	49	11
RT_Diesel	148	65	50	163	41
SUSht_Gas	902	367	302	988	229
SUSht_Diesel	3,021	1,399	1,012	3,310	870
SULht_Gas	73	11	25	80	7
SULht_Diesel	245	42	82	269	26
MH_Gas	35	13	12	38	8
MH_Diesel	117	51	39	128	32
CShT_Gas	122	24	17	122	16
CShT_Diesel	770	120	108	774	81
CLhT_Gas	0	0	0	0	0
CLhT_Diesel	1,098	425	154	1,104	286

2017 24-Hour Weekday SHP Summaries

SUT_FT	Gregg	Harrison	Rusk	Smith	Upshur
MC_Gas	55,741	37,026	21,966	105,131	26,714
PC_Gas	1,475,911	685,152	449,788	2,823,191	412,287
PC_Diesel	10,413	4,836	3,173	19,919	2,910
PT_Gas	603,807	354,669	236,651	1,031,075	222,745
PT_Diesel	9,813	5,764	3,846	16,757	3,620
LCT_Gas	148,009	86,935	58,010	252,744	54,598
LCT_Diesel	8,275	4,867	3,243	14,131	3,057
IBus_Diesel	619	404	205	661	255
TBus_Gas	0	0	0	0	0
TBus_Diesel	1,215	797	402	1,295	502
SBus_Gas	22	22	7	23	14
SBus_Diesel	3,370	2,194	1,116	3,594	1,383
RT_Gas	1,041	391	341	1,108	247
RT_Diesel	3,468	1,489	1,137	3,692	939
SUSht_Gas	21,083	8,378	6,916	22,450	5,285
SUSht_Diesel	70,600	31,905	23,159	75,178	20,125
SULht_Gas	1,710	249	561	1,821	157
SULht_Diesel	5,732	954	1,880	6,102	603
MH_Gas	809	304	265	861	192
MH_Diesel	2,728	1,174	895	2,905	740
CShT_Gas	2,642	174	261	2,208	245
CShT_Diesel	16,730	856	1,651	13,983	1,203
CLhT_Gas	0	0	0	0	0
CLhT_Diesel	23,601	2,271	2,219	19,235	4,032

2017 24-Hour Weekday Starts Summaries

SUT_FT	Gregg	Harrison	Rusk	Smith	Upshur
MC_Gas	1,053	700	415	1,987	505
PC_Gas	345,084	160,747	105,564	656,567	95,929
PC_Diesel	2,435	1,135	745	4,632	677
PT_Gas	144,628	84,995	56,845	247,635	53,080
PT_Diesel	2,351	1,381	924	4,025	863
LCT_Gas	38,250	22,478	15,034	65,492	14,038
LCT_Diesel	2,139	1,258	841	3,662	786
IBus_Diesel	77	51	26	84	32
TBus_Gas	0	0	0	0	0
TBus_Diesel	249	165	84	273	103
SBus_Gas	6	6	2	6	3
SBus_Diesel	855	563	287	937	351
RT_Gas	171	66	57	188	41
RT_Diesel	571	251	191	626	156
SUSht_Gas	6,445	2,624	2,159	7,061	1,633
SUSht_Diesel	21,582	9,994	7,231	23,644	6,217
SULht_Gas	326	49	109	357	30
SULht_Diesel	1,091	186	366	1,195	116
MH_Gas	20	8	7	22	5
MH_Diesel	67	29	22	73	18
CShT_Gas	738	148	103	742	100
CShT_Diesel	4,672	730	654	4,697	490
CLhT_Gas	0	0	0	0	0
CLhT_Diesel	4,709	1,822	659	4,734	1,224

2017 24-hour Weekday SHI and APU Hours Summaries (CLhT_Diesel Only)

County	2017		
	Hotelling	SHI	APU
Gregg	1,647	1,257	60
Harrison	2,271	1,734	83
Rusk	613	468	22
Smith	5,418	4,136	199
Upshur	405	309	15

Note: Hotelling includes Engine-off and Battery APU hours.

APPENDIX G:
SOURCE TYPE AGE DISTRIBUTION AND FUEL/ENGINE FRACTIONS INPUTS TO MOVES

Gregg County Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	Tbus	Sbus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.037190	0.044424	0.031284	0.031284	0.055550	0.055650	0.055556	0.064759	0.078282	0.080736	0.064928	0.022716	0.044007
1	0.058770	0.070922	0.051559	0.051559	0.049845	0.049946	0.049851	0.058272	0.090841	0.097975	0.058445	0.035336	0.048909
2	0.052801	0.069171	0.051398	0.051398	0.046006	0.046100	0.046012	0.053507	0.165514	0.150497	0.053673	0.044422	0.050486
3	0.033976	0.065983	0.061180	0.061180	0.042195	0.055697	0.032610	0.028999	0.129493	0.104892	0.039988	0.049975	0.032874
4	0.023416	0.054220	0.049396	0.049396	0.037253	0.034095	0.035647	0.022977	0.039480	0.036093	0.035305	0.022211	0.017742
5	0.082185	0.045084	0.034836	0.034836	0.031055	0.034678	0.042221	0.030317	0.033539	0.034013	0.029436	0.033821	0.031415
6	0.085399	0.068246	0.066992	0.066992	0.039993	0.048515	0.046183	0.023359	0.091142	0.093698	0.037928	0.047451	0.043640
7	0.101010	0.070559	0.069671	0.069671	0.052281	0.047012	0.047736	0.081433	0.058956	0.057695	0.049441	0.089854	0.094086
8	0.085859	0.064958	0.058275	0.058275	0.053396	0.033713	0.055776	0.060642	0.058881	0.064010	0.050348	0.064109	0.070679
9	0.070248	0.065190	0.050591	0.050591	0.055068	0.052558	0.049572	0.057049	0.051812	0.057569	0.051939	0.060071	0.061342
10	0.049128	0.058268	0.058985	0.058985	0.053504	0.043092	0.048835	0.034170	0.039254	0.040882	0.050306	0.044422	0.041119
11	0.056015	0.052254	0.053206	0.053206	0.049302	0.041983	0.041807	0.033378	0.032712	0.033007	0.046365	0.034326	0.032913
12	0.043618	0.048372	0.050203	0.050203	0.046065	0.042452	0.043802	0.024143	0.022710	0.026419	0.043333	0.035336	0.032437
13	0.032140	0.041962	0.054207	0.054207	0.044039	0.048613	0.039741	0.029530	0.025643	0.027473	0.041306	0.044927	0.043530
14	0.035813	0.037485	0.040098	0.040098	0.041778	0.032808	0.043136	0.040271	0.017747	0.021921	0.039197	0.048460	0.052520
15	0.023875	0.030497	0.034642	0.034642	0.040614	0.031806	0.039913	0.057676	0.017221	0.019697	0.037984	0.042908	0.044225
16	0.019743	0.021824	0.027636	0.027636	0.030599	0.037111	0.031314	0.052718	0.008046	0.009478	0.022205	0.036345	0.037120
17	0.013774	0.017892	0.026894	0.026894	0.024835	0.033826	0.029099	0.025424	0.008874	0.010221	0.034115	0.024735	0.028101
18	0.012397	0.015083	0.019726	0.019726	0.020413	0.030975	0.024947	0.032795	0.004061	0.005665	0.020938	0.029278	0.025898
19	0.010101	0.013266	0.020436	0.020436	0.026465	0.025322	0.031789	0.041994	0.004813	0.006044	0.024651	0.027764	0.032080
20	0.009183	0.007798	0.017499	0.017499	0.020257	0.021951	0.015251	0.029313	0.003309	0.003876	0.023297	0.017668	0.020867
21	0.007346	0.006740	0.011752	0.011752	0.016634	0.018163	0.018167	0.013318	0.002331	0.002748	0.015998	0.026754	0.017990
22	0.003214	0.005617	0.008652	0.008652	0.012252	0.015769	0.014653	0.011855	0.001805	0.001875	0.013989	0.019182	0.012870
23	0.002296	0.003981	0.007426	0.007426	0.013802	0.015855	0.018594	0.018450	0.001203	0.002168	0.010346	0.018677	0.014209
24	0.001837	0.002842	0.006522	0.006522	0.015451	0.023149	0.020950	0.013061	0.001654	0.001735	0.013522	0.012115	0.012572
25	0.004591	0.002082	0.005295	0.005295	0.015325	0.017611	0.011953	0.020123	0.001654	0.001442	0.017413	0.011106	0.009605
26	0.002755	0.001817	0.003777	0.003777	0.014173	0.013781	0.014128	0.011515	0.001128	0.001180	0.015355	0.007572	0.007859
27	0.003214	0.001520	0.003455	0.003455	0.014696	0.012718	0.014276	0.010304	0.000677	0.000678	0.014965	0.006058	0.006202
28	0.003214	0.001107	0.003293	0.003293	0.012327	0.010714	0.012460	0.005268	0.000902	0.000875	0.010998	0.004543	0.006083
29	0.005051	0.001355	0.003325	0.003325	0.010702	0.009139	0.010634	0.005263	0.000602	0.000762	0.011609	0.009591	0.005596
30	0.029844	0.009483	0.017789	0.017789	0.014149	0.015191	0.013386	0.008114	0.005715	0.004677	0.020675	0.028269	0.021026

Note: The local vehicle age distributions were developed using 2014 mid-year TxDMV vehicle registration data (latest available).

Harrison County Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	Tbus	Sbus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.026104	0.039140	0.018082	0.018082	0.055550	0.055650	0.055556	0.064759	0.078282	0.080736	0.064928	0.022716	0.044007
1	0.046854	0.068599	0.044993	0.044993	0.049845	0.049946	0.049851	0.058272	0.090841	0.097975	0.058445	0.035336	0.048909
2	0.063588	0.066470	0.044727	0.044727	0.046006	0.046100	0.046012	0.053507	0.165514	0.150497	0.053673	0.044422	0.050486
3	0.038822	0.059912	0.052385	0.052385	0.042195	0.055697	0.032610	0.028999	0.129493	0.104892	0.039988	0.049975	0.032874
4	0.032129	0.052496	0.041908	0.041908	0.037253	0.034095	0.035647	0.022977	0.039480	0.036093	0.035305	0.022211	0.017742
5	0.080321	0.045011	0.033452	0.033452	0.031055	0.034678	0.042221	0.030317	0.033539	0.034013	0.029436	0.033821	0.031415
6	0.068942	0.064616	0.061054	0.061054	0.039993	0.048515	0.046183	0.023359	0.091142	0.093698	0.037928	0.047451	0.043640
7	0.096386	0.065886	0.065947	0.065947	0.052281	0.047012	0.047736	0.081433	0.058956	0.057695	0.049441	0.089854	0.094086
8	0.085007	0.063105	0.056534	0.056534	0.053396	0.033713	0.055776	0.060642	0.058881	0.064010	0.050348	0.064109	0.070679
9	0.069612	0.064581	0.052970	0.052970	0.055068	0.052558	0.049572	0.057049	0.051812	0.057569	0.051939	0.060071	0.061342
10	0.046854	0.057577	0.057863	0.057863	0.053504	0.043092	0.048835	0.034170	0.039254	0.040882	0.050306	0.044422	0.041119
11	0.060910	0.053183	0.056746	0.056746	0.049302	0.041983	0.041807	0.033378	0.032712	0.033007	0.046365	0.034326	0.032913
12	0.051539	0.049509	0.052332	0.052332	0.046065	0.042452	0.043802	0.024143	0.022710	0.026419	0.043333	0.035336	0.032437
13	0.038153	0.045286	0.055470	0.055470	0.044039	0.048613	0.039741	0.029530	0.025643	0.027473	0.041306	0.044927	0.043530
14	0.032798	0.038522	0.042546	0.042546	0.041778	0.032808	0.043136	0.040271	0.017747	0.021921	0.039197	0.048460	0.052520
15	0.026104	0.031724	0.035154	0.035154	0.040614	0.031806	0.039913	0.057676	0.017221	0.019697	0.037984	0.042908	0.044225
16	0.017403	0.025064	0.028134	0.028134	0.030599	0.037111	0.031314	0.052718	0.008046	0.009478	0.022205	0.036345	0.037120
17	0.014726	0.020085	0.033239	0.033239	0.024835	0.033826	0.029099	0.025424	0.008874	0.010221	0.034115	0.024735	0.028101
18	0.015395	0.016171	0.026538	0.026538	0.020413	0.030975	0.024947	0.032795	0.004061	0.005665	0.020938	0.029278	0.025898
19	0.013387	0.015381	0.023613	0.023613	0.026465	0.025322	0.031789	0.041994	0.004813	0.006044	0.024651	0.027764	0.032080
20	0.011379	0.011296	0.022071	0.022071	0.020257	0.021951	0.015251	0.029313	0.003309	0.003876	0.023297	0.017668	0.020867
21	0.008032	0.007656	0.015636	0.015636	0.016634	0.018163	0.018167	0.013318	0.002331	0.002748	0.015998	0.026754	0.017990
22	0.005355	0.006352	0.010637	0.010637	0.012252	0.015769	0.014653	0.011855	0.001805	0.001875	0.013989	0.019182	0.012870
23	0.002677	0.004669	0.010211	0.010211	0.013802	0.015855	0.018594	0.018450	0.001203	0.002168	0.010346	0.018677	0.014209
24	0.002677	0.004017	0.006542	0.006542	0.015451	0.023149	0.020950	0.013061	0.001654	0.001735	0.013522	0.012115	0.012572
25	0.004685	0.003433	0.007073	0.007073	0.015325	0.017611	0.011953	0.020123	0.001654	0.001442	0.017413	0.011106	0.009605
26	0.002677	0.002506	0.005744	0.005744	0.014173	0.013781	0.014128	0.011515	0.001128	0.001180	0.015355	0.007572	0.007859
27	0.004016	0.001888	0.004308	0.004308	0.014696	0.012718	0.014276	0.010304	0.000677	0.000678	0.014965	0.006058	0.006202
28	0.007363	0.001717	0.004680	0.004680	0.012327	0.010714	0.012460	0.005268	0.000902	0.000875	0.010998	0.004543	0.006083
29	0.001339	0.001751	0.005106	0.005106	0.010702	0.009139	0.010634	0.005263	0.000602	0.000762	0.011609	0.009591	0.005596
30	0.024766	0.012394	0.024305	0.024305	0.014149	0.015191	0.013386	0.008114	0.005715	0.004677	0.020675	0.028269	0.021026

Note: The local vehicle age distributions were developed using 2014 mid-year TxDMV vehicle registration data (latest available).

Rusk County Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	Tbus	Sbus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.027664	0.037322	0.025061	0.025061	0.055550	0.055650	0.055556	0.064759	0.078282	0.080736	0.064928	0.022716	0.044007
1	0.038934	0.069658	0.047378	0.047378	0.049845	0.049946	0.049851	0.058272	0.090841	0.097975	0.058445	0.035336	0.048909
2	0.045082	0.067806	0.046656	0.046656	0.046006	0.046100	0.046012	0.053507	0.165514	0.150497	0.053673	0.044422	0.050486
3	0.030738	0.067569	0.045862	0.045862	0.042195	0.055697	0.032610	0.028999	0.129493	0.104892	0.039988	0.049975	0.032874
4	0.042008	0.056458	0.042612	0.042612	0.037253	0.034095	0.035647	0.022977	0.039480	0.036093	0.035305	0.022211	0.017742
5	0.071721	0.046819	0.028311	0.028311	0.031055	0.034678	0.042221	0.030317	0.033539	0.034013	0.029436	0.033821	0.031415
6	0.065574	0.064815	0.056840	0.056840	0.039993	0.048515	0.046183	0.023359	0.091142	0.093698	0.037928	0.047451	0.043640
7	0.100410	0.072460	0.063412	0.063412	0.052281	0.047012	0.047736	0.081433	0.058956	0.057695	0.049441	0.089854	0.094086
8	0.075820	0.062631	0.052867	0.052867	0.053396	0.033713	0.055776	0.060642	0.058881	0.064010	0.050348	0.064109	0.070679
9	0.078893	0.062583	0.055540	0.055540	0.055068	0.052558	0.049572	0.057049	0.051812	0.057569	0.051939	0.060071	0.061342
10	0.052254	0.055318	0.056406	0.056406	0.053504	0.043092	0.048835	0.034170	0.039254	0.040882	0.050306	0.044422	0.041119
11	0.061475	0.047436	0.053878	0.053878	0.049302	0.041983	0.041807	0.033378	0.032712	0.033007	0.046365	0.034326	0.032913
12	0.050205	0.047768	0.057634	0.057634	0.046065	0.042452	0.043802	0.024143	0.022710	0.026419	0.043333	0.035336	0.032437
13	0.048156	0.041216	0.058356	0.058356	0.044039	0.048613	0.039741	0.029530	0.025643	0.027473	0.041306	0.044927	0.043530
14	0.023566	0.038699	0.043912	0.043912	0.041778	0.032808	0.043136	0.040271	0.017747	0.021921	0.039197	0.048460	0.052520
15	0.035861	0.031149	0.035823	0.035823	0.040614	0.031806	0.039913	0.057676	0.017221	0.019697	0.037984	0.042908	0.044225
16	0.025615	0.024311	0.030189	0.030189	0.030599	0.037111	0.031314	0.052718	0.008046	0.009478	0.022205	0.036345	0.037120
17	0.014344	0.020893	0.034667	0.034667	0.024835	0.033826	0.029099	0.025424	0.008874	0.010221	0.034115	0.024735	0.028101
18	0.015369	0.013865	0.026289	0.026289	0.020413	0.030975	0.024947	0.032795	0.004061	0.005665	0.020938	0.029278	0.025898
19	0.012295	0.015385	0.023761	0.023761	0.026465	0.025322	0.031789	0.041994	0.004813	0.006044	0.024651	0.027764	0.032080
20	0.006148	0.010399	0.021595	0.021595	0.020257	0.021951	0.015251	0.029313	0.003309	0.003876	0.023297	0.017668	0.020867
21	0.012295	0.008642	0.015239	0.015239	0.016634	0.018163	0.018167	0.013318	0.002331	0.002748	0.015998	0.026754	0.017990
22	0.005123	0.005983	0.012422	0.012422	0.012252	0.015769	0.014653	0.011855	0.001805	0.001875	0.013989	0.019182	0.012870
23	0.003074	0.005271	0.009100	0.009100	0.013802	0.015855	0.018594	0.018450	0.001203	0.002168	0.010346	0.018677	0.014209
24	0.001025	0.004179	0.008450	0.008450	0.015451	0.023149	0.020950	0.013061	0.001654	0.001735	0.013522	0.012115	0.012572
25	0.004098	0.002896	0.007728	0.007728	0.015325	0.017611	0.011953	0.020123	0.001654	0.001442	0.017413	0.011106	0.009605
26	0.004098	0.002137	0.005128	0.005128	0.014173	0.013781	0.014128	0.011515	0.001128	0.001180	0.015355	0.007572	0.007859
27	0.004098	0.001425	0.003972	0.003972	0.014696	0.012718	0.014276	0.010304	0.000677	0.000678	0.014965	0.006058	0.006202
28	0.005123	0.001235	0.005056	0.005056	0.012327	0.010714	0.012460	0.005268	0.000902	0.000875	0.010998	0.004543	0.006083
29	0.003074	0.001852	0.003756	0.003756	0.010702	0.009139	0.010634	0.005263	0.000602	0.000762	0.011609	0.009591	0.005596
30	0.035861	0.011823	0.022100	0.022100	0.014149	0.015191	0.013386	0.008114	0.005715	0.004677	0.020675	0.028269	0.021026

Note: The local vehicle age distributions were developed using 2014 mid-year TxDMV vehicle registration data (latest available).

Smith County Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	Tbus	Sbus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.023232	0.043343	0.024077	0.024077	0.055550	0.055650	0.055556	0.064759	0.078282	0.080736	0.064928	0.022716	0.044007
1	0.046202	0.069605	0.044393	0.044393	0.049845	0.049946	0.049851	0.058272	0.090841	0.097975	0.058445	0.035336	0.048909
2	0.045158	0.064894	0.039926	0.039926	0.046006	0.046100	0.046012	0.053507	0.165514	0.150497	0.053673	0.044422	0.050486
3	0.031062	0.061022	0.044009	0.044009	0.042195	0.055697	0.032610	0.028999	0.129493	0.104892	0.039988	0.049975	0.032874
4	0.027147	0.054049	0.037136	0.037136	0.037253	0.034095	0.035647	0.022977	0.039480	0.036093	0.035305	0.022211	0.017742
5	0.069956	0.045801	0.030829	0.030829	0.031055	0.034678	0.042221	0.030317	0.033539	0.034013	0.029436	0.033821	0.031415
6	0.075437	0.067817	0.057432	0.057432	0.039993	0.048515	0.046183	0.023359	0.091142	0.093698	0.037928	0.047451	0.043640
7	0.096581	0.072947	0.064083	0.064083	0.052281	0.047012	0.047736	0.081433	0.058956	0.057695	0.049441	0.089854	0.094086
8	0.085878	0.065434	0.055047	0.055047	0.053396	0.033713	0.055776	0.060642	0.058881	0.064010	0.050348	0.064109	0.070679
9	0.070217	0.065890	0.055492	0.055492	0.055068	0.052558	0.049572	0.057049	0.051812	0.057569	0.051939	0.060071	0.061342
10	0.057948	0.056535	0.064265	0.064265	0.053504	0.043092	0.048835	0.034170	0.039254	0.040882	0.050306	0.044422	0.041119
11	0.059514	0.053602	0.061738	0.061738	0.049302	0.041983	0.041807	0.033378	0.032712	0.033007	0.046365	0.034326	0.032913
12	0.063169	0.050251	0.057978	0.057978	0.046065	0.042452	0.043802	0.024143	0.022710	0.026419	0.043333	0.035336	0.032437
13	0.040198	0.042627	0.057311	0.057311	0.044039	0.048613	0.039741	0.029530	0.025643	0.027473	0.041306	0.044927	0.043530
14	0.033412	0.038289	0.047668	0.047668	0.041778	0.032808	0.043136	0.040271	0.017747	0.021921	0.039197	0.048460	0.052520
15	0.028452	0.030925	0.038288	0.038288	0.040614	0.031806	0.039913	0.057676	0.017221	0.019697	0.037984	0.042908	0.044225
16	0.020882	0.022677	0.031213	0.031213	0.030599	0.037111	0.031314	0.052718	0.008046	0.009478	0.022205	0.036345	0.037120
17	0.020621	0.018767	0.030990	0.030990	0.024835	0.033826	0.029099	0.025424	0.008874	0.010221	0.034115	0.024735	0.028101
18	0.016967	0.013591	0.023147	0.023147	0.020413	0.030975	0.024947	0.032795	0.004061	0.005665	0.020938	0.029278	0.025898
19	0.012007	0.013135	0.024218	0.024218	0.026465	0.025322	0.031789	0.041994	0.004813	0.006044	0.024651	0.027764	0.032080
20	0.007309	0.008704	0.020418	0.020418	0.020257	0.021951	0.015251	0.029313	0.003309	0.003876	0.023297	0.017668	0.020867
21	0.006787	0.006824	0.013908	0.013908	0.016634	0.018163	0.018167	0.013318	0.002331	0.002748	0.015998	0.026754	0.017990
22	0.004176	0.005343	0.010795	0.010795	0.012252	0.015769	0.014653	0.011855	0.001805	0.001875	0.013989	0.019182	0.012870
23	0.004699	0.004357	0.009097	0.009097	0.013802	0.015855	0.018594	0.018450	0.001203	0.002168	0.010346	0.018677	0.014209
24	0.002871	0.003035	0.007278	0.007278	0.015451	0.023149	0.020950	0.013061	0.001654	0.001735	0.013522	0.012115	0.012572
25	0.004699	0.002970	0.006893	0.006893	0.015325	0.017611	0.011953	0.020123	0.001654	0.001442	0.017413	0.011106	0.009605
26	0.003132	0.001918	0.005640	0.005640	0.014173	0.013781	0.014128	0.011515	0.001128	0.001180	0.015355	0.007572	0.007859
27	0.002349	0.001648	0.003477	0.003477	0.014696	0.012718	0.014276	0.010304	0.000677	0.000678	0.014965	0.006058	0.006202
28	0.004176	0.001378	0.004650	0.004650	0.012327	0.010714	0.012460	0.005268	0.000902	0.000875	0.010998	0.004543	0.006083
29	0.005482	0.001564	0.004185	0.004185	0.010702	0.009139	0.010634	0.005263	0.000602	0.000762	0.011609	0.009591	0.005596
30	0.030279	0.011059	0.024420	0.024420	0.014149	0.015191	0.013386	0.008114	0.005715	0.004677	0.020675	0.028269	0.021026

Note: The local vehicle age distributions were developed using 2014 mid-year TxDMV vehicle registration data (latest available).

Upshur County Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	Tbus	Sbus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.015519	0.038364	0.019404	0.019404	0.055550	0.055650	0.055556	0.064759	0.078282	0.080736	0.064928	0.022716	0.044007
1	0.044617	0.069152	0.037650	0.037650	0.049845	0.049946	0.049851	0.058272	0.090841	0.097975	0.058445	0.035336	0.048909
2	0.059166	0.071978	0.039163	0.039163	0.046006	0.046100	0.046012	0.053507	0.165514	0.150497	0.053673	0.044422	0.050486
3	0.036857	0.067949	0.043258	0.043258	0.042195	0.055697	0.032610	0.028999	0.129493	0.104892	0.039988	0.049975	0.032874
4	0.025218	0.054961	0.035781	0.035781	0.037253	0.034095	0.035647	0.022977	0.039480	0.036093	0.035305	0.022211	0.017742
5	0.071775	0.043416	0.028393	0.028393	0.031055	0.034678	0.042221	0.030317	0.033539	0.034013	0.029436	0.033821	0.031415
6	0.079534	0.066566	0.055897	0.055897	0.039993	0.048515	0.046183	0.023359	0.091142	0.093698	0.037928	0.047451	0.043640
7	0.103783	0.066867	0.055986	0.055986	0.052281	0.047012	0.047736	0.081433	0.058956	0.057695	0.049441	0.089854	0.094086
8	0.089234	0.063500	0.054473	0.054473	0.053396	0.033713	0.055776	0.060642	0.058881	0.064010	0.050348	0.064109	0.070679
9	0.082444	0.063139	0.054473	0.054473	0.055068	0.052558	0.049572	0.057049	0.051812	0.057569	0.051939	0.060071	0.061342
10	0.069835	0.053337	0.060881	0.060881	0.053504	0.043092	0.048835	0.034170	0.039254	0.040882	0.050306	0.044422	0.041119
11	0.042677	0.051654	0.059724	0.059724	0.049302	0.041983	0.041807	0.033378	0.032712	0.033007	0.046365	0.034326	0.032913
12	0.032978	0.048767	0.061593	0.061593	0.046065	0.042452	0.043802	0.024143	0.022710	0.026419	0.043333	0.035336	0.032437
13	0.048497	0.040710	0.062038	0.062038	0.044039	0.048613	0.039741	0.029530	0.025643	0.027473	0.041306	0.044927	0.043530
14	0.036857	0.038785	0.047975	0.047975	0.041778	0.032808	0.043136	0.040271	0.017747	0.021921	0.039197	0.048460	0.052520
15	0.023278	0.031449	0.045394	0.045394	0.040614	0.031806	0.039913	0.057676	0.017221	0.019697	0.037984	0.042908	0.044225
16	0.016489	0.023151	0.030530	0.030530	0.030599	0.037111	0.031314	0.052718	0.008046	0.009478	0.022205	0.036345	0.037120
17	0.010669	0.020265	0.034624	0.034624	0.024835	0.033826	0.029099	0.025424	0.008874	0.010221	0.034115	0.024735	0.028101
18	0.020369	0.015093	0.028304	0.028304	0.020413	0.030975	0.024947	0.032795	0.004061	0.005665	0.020938	0.029278	0.025898
19	0.015519	0.013830	0.025723	0.025723	0.026465	0.025322	0.031789	0.041994	0.004813	0.006044	0.024651	0.027764	0.032080
20	0.006790	0.010583	0.023854	0.023854	0.020257	0.021951	0.015251	0.029313	0.003309	0.003876	0.023297	0.017668	0.020867
21	0.004850	0.009020	0.017802	0.017802	0.016634	0.018163	0.018167	0.013318	0.002331	0.002748	0.015998	0.026754	0.017990
22	0.005820	0.007637	0.011215	0.011215	0.012252	0.015769	0.014653	0.011855	0.001805	0.001875	0.013989	0.019182	0.012870
23	0.003880	0.004330	0.011571	0.011571	0.013802	0.015855	0.018594	0.018450	0.001203	0.002168	0.010346	0.018677	0.014209
24	0.002910	0.003428	0.009791	0.009791	0.015451	0.023149	0.020950	0.013061	0.001654	0.001735	0.013522	0.012115	0.012572
25	0.001940	0.003307	0.007566	0.007566	0.015325	0.017611	0.011953	0.020123	0.001654	0.001442	0.017413	0.011106	0.009605
26	0.000970	0.002826	0.003738	0.003738	0.014173	0.013781	0.014128	0.011515	0.001128	0.001180	0.015355	0.007572	0.007859
27	0.004850	0.001624	0.003471	0.003471	0.014696	0.012718	0.014276	0.010304	0.000677	0.000678	0.014965	0.006058	0.006202
28	0.004850	0.000842	0.004005	0.004005	0.012327	0.010714	0.012460	0.005268	0.000902	0.000875	0.010998	0.004543	0.006083
29	0.002910	0.001443	0.003738	0.003738	0.010702	0.009139	0.010634	0.005263	0.000602	0.000762	0.011609	0.009591	0.005596
30	0.034918	0.012026	0.021985	0.021985	0.014149	0.015191	0.013386	0.008114	0.005715	0.004677	0.020675	0.028269	0.021026

Note: The local vehicle age distributions were developed using 2014 mid-year TxDMV vehicle registration data (latest available).

Texas Statewide 2017 Fuel Engine Fractions Summary

SUT	Fuel Type	Model Year															
		2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
MC	Gas	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
PC	Gas	0.9883	0.9883	0.9883	0.9883	0.9883	0.9883	0.9883	0.9899	0.9926	0.9995	0.9997	0.9931	0.9952	0.9969	0.9961	0.9957
PC	Diesel	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0101	0.0074	0.0005	0.0003	0.0069	0.0048	0.0031	0.0039	0.0043
PT	Gas	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9872	0.9845	0.9771	0.9805	0.9749	0.9793	0.9816	0.9816	0.9834
PT	Diesel	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0128	0.0155	0.0229	0.0195	0.0251	0.0207	0.0184	0.0184	0.0166
LCT	Gas	0.9469	0.9469	0.9469	0.9469	0.9469	0.9469	0.9469	0.9621	0.9554	0.9406	0.9479	0.9380	0.9464	0.9512	0.9509	0.9557
LCT	Diesel	0.0531	0.0531	0.0531	0.0531	0.0531	0.0531	0.0531	0.0379	0.0446	0.0594	0.0521	0.0620	0.0536	0.0488	0.0491	0.0443
IBus	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
TBus	Gas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TBus	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SBus	Gas	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
SBus	Diesel	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900
RT	Gas	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0021	0.0015	0.0054	0.0014	0.0029	0.0027	0.0050	0.0043	0.0054
RT	Diesel	0.9969	0.9969	0.9969	0.9969	0.9969	0.9969	0.9969	0.9979	0.9985	0.9946	0.9986	0.9971	0.9973	0.9950	0.9957	0.9946
SUShT	Gas	0.3959	0.3959	0.3959	0.3959	0.3705	0.2191	0.2339	0.2736	0.3508	0.2872	0.2558	0.2382	0.2320	0.2454	0.2601	0.2677
SUShT	Diesel	0.6041	0.6041	0.6041	0.6041	0.6295	0.7809	0.7661	0.7264	0.6492	0.7128	0.7442	0.7618	0.7680	0.7546	0.7399	0.7323
SULhT	Gas	0.3959	0.3959	0.3959	0.3959	0.3705	0.2191	0.2339	0.2736	0.3508	0.2872	0.2558	0.2382	0.2320	0.2454	0.2601	0.2677
SULhT	Diesel	0.6041	0.6041	0.6041	0.6041	0.6295	0.7809	0.7661	0.7264	0.6492	0.7128	0.7442	0.7618	0.7680	0.7546	0.7399	0.7323
MH	Gas	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5100	0.5300	0.5400	0.5600	0.5700	0.5900	0.6000
MH	Diesel	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.4900	0.4700	0.4600	0.4400	0.4300	0.4100	0.4000
CShT	Gas	0.0936	0.0936	0.0936	0.0936	0.1988	0.1099	0.0570	0.0805	0.0524	0.0582	0.0306	0.0500	0.0513	0.0516	0.0549	0.0768
CShT	Diesel	0.9064	0.9064	0.9064	0.9064	0.8012	0.8901	0.9430	0.9195	0.9476	0.9418	0.9694	0.9500	0.9487	0.9484	0.9451	0.9232
CLhT	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Note: Conventional Internal Combustion engine technology only.

Texas Statewide 2017 Fuel Engine Fractions Summary - Continued

SUT	Fuel Type	Model Year														
		2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987
MC	Gas	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
PC	Gas	0.9970	0.9974	0.9981	0.9978	0.9991	0.9988	0.9991	0.9998	0.9993	0.9988	0.9972	0.9989	0.9991	0.9997	0.9872
PC	Diesel	0.0030	0.0026	0.0019	0.0022	0.0009	0.0012	0.0009	0.0002	0.0007	0.0012	0.0028	0.0011	0.0009	0.0003	0.0128
PT	Gas	0.9889	0.9917	0.9813	0.9925	0.9916	0.9813	0.9949	0.9914	0.9864	0.9846	0.9942	0.9891	0.9922	0.9974	0.9964
PT	Diesel	0.0111	0.0083	0.0187	0.0075	0.0084	0.0187	0.0051	0.0086	0.0136	0.0154	0.0058	0.0109	0.0078	0.0026	0.0036
LCT	Gas	0.9077	0.9492	0.9294	0.9495	0.9270	0.9708	0.9316	0.9743	0.9736	0.9512	0.9370	0.9844	0.9762	0.9521	0.9862
LCT	Diesel	0.0923	0.0508	0.0706	0.0505	0.0730	0.0292	0.0684	0.0257	0.0264	0.0488	0.0630	0.0156	0.0238	0.0479	0.0138
IBus	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
TBus	Gas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TBus	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SBus	Gas	0.0100	0.0100	0.0100	0.0100	0.0100	0.0415	0.1143	0.1474	0.1205	0.0100	0.0895	0.1241	0.2290	0.2498	0.2655
SBus	Diesel	0.9900	0.9900	0.9900	0.9900	0.9900	0.9585	0.8857	0.8526	0.8795	0.9900	0.9105	0.8759	0.7710	0.7502	0.7345
RT	Gas	0.0063	0.0021	0.1688	0.4036	0.0193	0.0122	0.0100	0.1050	0.0315	0.2103	0.1012	0.2040	0.0294	0.1065	0.1064
RT	Diesel	0.9937	0.9979	0.8312	0.5964	0.9807	0.9878	0.9900	0.8950	0.9685	0.7897	0.8988	0.7960	0.9706	0.8935	0.8936
SUShT	Gas	0.3113	0.3505	0.3481	0.4345	0.4359	0.4270	0.6731	0.5076	0.5194	0.5112	0.4653	0.5392	0.5718	0.6401	0.6543
SUShT	Diesel	0.6887	0.6495	0.6519	0.5655	0.5641	0.5730	0.3269	0.4924	0.4806	0.4888	0.5347	0.4608	0.4282	0.3599	0.3457
SULhT	Gas	0.3113	0.3505	0.3481	0.4345	0.4359	0.4270	0.6731	0.5076	0.5194	0.5112	0.4653	0.5392	0.5718	0.6401	0.6543
SULhT	Diesel	0.6887	0.6495	0.6519	0.5655	0.5641	0.5730	0.3269	0.4924	0.4806	0.4888	0.5347	0.4608	0.4282	0.3599	0.3457
MH	Gas	0.6300	0.6600	0.6800	0.7100	0.7400	0.7700	0.7900	0.8200	0.8500	0.8500	0.8499	0.8500	0.8500	0.8500	0.8500
MH	Diesel	0.3700	0.3400	0.3200	0.2900	0.2600	0.2300	0.2100	0.1800	0.1500	0.1500	0.1501	0.1500	0.1500	0.1500	0.1500
CShT	Gas	0.0843	0.0899	0.1075	0.1337	0.1472	0.1456	0.2747	0.1170	0.1169	0.1604	0.1613	0.1444	0.1136	0.1566	0.1632
CShT	Diesel	0.9157	0.9101	0.8925	0.8663	0.8528	0.8544	0.7253	0.8830	0.8831	0.8396	0.8387	0.8556	0.8864	0.8434	0.8368
CLhT	Diesel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Note: Conventional Internal Combustion engine technology only.

APPENDIX H:
METEOROLOGICAL INPUTS TO MOVES

TLM Area Summer Season Temperature Inputs (Degrees Fahrenheit)[1]

Hour[2]	Gregg	Harrison	Rusk	Smith	Upshur
1	76.75	75.04	75.54	77.30	75.72
2	76.05	74.52	75.10	76.60	75.04
3	75.52	74.06	74.54	75.88	74.54
4	75.04	73.65	74.07	75.35	73.83
5	74.63	73.20	73.71	74.84	73.25
6	74.26	72.86	73.31	74.40	72.90
7	74.15	72.62	72.95	74.24	72.57
8	75.28	73.36	73.53	75.26	72.82
9	77.45	75.37	75.74	77.00	74.72
10	79.57	77.95	78.45	78.96	76.99
11	81.59	80.08	80.61	80.73	79.01
12	83.33	82.03	82.65	82.60	81.14
13	84.90	83.73	84.40	84.21	83.08
14	86.16	84.81	85.80	85.53	84.41
15	87.00	85.71	86.96	86.59	85.52
16	87.53	86.38	87.34	87.25	85.77
17	87.52	86.30	87.44	87.24	86.12
18	86.93	85.50	87.21	86.87	85.97
19	85.46	84.33	85.86	85.87	84.97
20	82.93	82.26	83.73	84.07	83.43
21	80.39	79.42	80.53	81.55	80.98
22	79.05	77.49	78.38	79.92	78.78
23	78.15	76.45	77.24	79.00	77.52
24	77.47	75.70	76.21	78.07	76.56

[1] Average hourly - June through August, 2017.

[2] Hour 1 is 12 a.m. to 1 a.m., etc.

TLM Area Summer Season Relative Humidity Inputs (Percent)[1]

Hour[2]	Gregg	Harrison	Rusk	Smith	Upshur
1	90.70	89.07	89.42	87.95	87.75
2	91.86	89.01	90.42	89.74	89.09
3	93.00	89.84	91.60	91.35	89.93
4	93.70	90.02	92.69	92.11	91.46
5	94.75	90.24	93.12	92.99	92.93
6	95.46	90.80	94.34	93.53	93.46
7	95.50	91.41	95.39	93.87	93.65
8	92.68	91.16	94.08	90.32	92.99
9	86.21	88.54	89.60	85.14	88.46
10	80.04	82.17	82.53	79.20	82.65
11	74.66	76.12	76.41	72.81	77.67
12	70.50	70.97	70.90	67.51	72.48
13	66.77	66.25	66.48	63.00	68.17
14	64.10	63.71	63.53	60.04	64.95
15	62.14	61.70	60.38	57.27	63.01
16	61.05	60.09	59.98	56.32	61.84
17	61.48	60.15	59.71	56.54	61.75
18	62.56	61.58	59.98	57.54	61.97
19	66.72	64.90	63.13	61.71	65.06
20	76.33	70.89	68.28	67.73	69.07
21	83.56	79.08	76.83	76.07	75.82
22	86.62	84.72	81.97	80.73	81.93
23	88.67	86.49	84.47	82.87	84.67
24	89.14	88.01	87.85	85.87	85.77

[1] Average hourly - June through August, 2017.

[2] Hour 1 is 12 a.m. to 1 a.m., etc.

TLM Area Summer and Winter Barometric Pressure (inches Mercury)

Gregg	Harrison	Rusk	Smith	Upshur
29.614	29.658	29.553	29.426	29.573

Note: Annual Average, 2017.

TLM Area Winter Season Temperature Inputs (Degrees Fahrenheit)[1]

Hour[2]	Gregg	Harrison	Rusk	Smith	Upshur
1	50.61	49.34	48.57	50.75	49.75
2	50.15	48.91	48.17	50.15	49.15
3	49.57	48.33	47.58	49.59	48.60
4	49.06	47.83	47.09	49.07	47.98
5	48.59	47.37	46.24	48.74	47.61
6	48.35	46.99	46.06	48.35	47.11
7	48.16	46.75	45.86	48.05	46.50
8	48.65	46.81	46.05	48.31	46.55
9	50.73	48.56	47.49	50.00	47.89
10	53.51	51.26	50.88	52.30	50.70
11	55.90	54.03	54.04	54.63	53.19
12	57.98	56.36	56.64	56.70	55.65
13	59.31	58.08	58.39	58.40	57.36
14	60.57	59.33	59.82	59.59	58.98
15	61.23	60.17	60.37	60.40	59.94
16	61.44	60.36	60.70	60.67	60.42
17	60.42	59.71	60.05	59.99	60.14
18	58.00	57.68	58.00	58.04	58.58
19	55.72	54.97	55.35	55.93	56.12
20	54.25	53.22	53.35	54.52	54.23
21	53.11	52.14	52.00	53.48	53.05
22	52.30	51.31	50.99	52.55	51.96
23	51.62	50.56	49.88	51.85	51.25
24	51.04	49.93	49.26	51.22	50.61

[1] Average hourly - December-January-February, 2017.

[2] Hour 1 is 12 a.m. to 1 a.m., etc.

TLM Area Winter Season Relative Humidity Inputs (Percent)[1]

Hour[2]	Gregg	Harrison	Rusk	Smith	Upshur
1	81.44	81.01	82.30	76.44	77.75
2	82.20	81.54	83.85	78.11	79.14
3	84.06	82.14	84.80	78.75	80.47
4	84.56	82.77	85.58	79.73	81.67
5	85.35	83.58	84.92	79.33	81.33
6	85.62	83.73	85.87	79.67	82.00
7	85.34	83.26	85.51	80.36	83.08
8	84.28	83.77	86.23	79.73	83.55
9	79.56	82.10	83.47	74.42	81.43
10	71.20	76.34	75.79	68.42	74.82
11	67.17	68.33	67.28	63.25	69.37
12	62.35	62.61	61.53	58.78	64.46
13	59.25	58.41	57.29	55.74	60.76
14	57.08	55.30	55.81	53.35	58.33
15	56.61	53.89	54.03	51.77	56.37
16	55.82	53.30	53.30	52.04	55.49
17	58.73	54.61	55.55	54.02	56.25
18	65.74	59.50	59.97	59.09	59.30
19	70.89	66.57	65.53	63.70	64.68
20	73.84	72.08	69.83	67.16	68.33
21	76.08	74.45	74.01	69.88	70.98
22	77.44	76.44	77.47	71.78	73.59
23	79.28	77.59	78.85	72.91	74.87
24	79.84	79.16	80.32	74.69	76.36

[1] Average hourly - December-January-February, 2017.

[2] Hour 1 is 12 a.m. to 1 a.m., etc.

APPENDIX I:
SUMMARY OF MOVES RUNS

This appendix was submitted electronically.

APPENDIX J:
ANNUAL ACTIVITY INPUTS

Day Type VMT Fractions by TxDOT District

Month	Atlanta		Tyler	
	Week Day[1]	Weekend Day[2]	Week Day[1]	Weekend Day[2]
January	0.719	0.281	0.767	0.233
February	0.725	0.275	0.759	0.241
March	0.750	0.250	0.770	0.230
April	0.736	0.264	0.760	0.240
May	0.721	0.279	0.741	0.259
June	0.724	0.276	0.743	0.257
July	0.726	0.274	0.753	0.247
August	0.718	0.282	0.753	0.247
September	0.741	0.259	0.762	0.238
October	0.737	0.263	0.761	0.239
November	0.709	0.291	0.762	0.238
December	0.736	0.264	0.765	0.235

[1] Monday through Friday (MOVES dayTypeID = 5).
[2] Saturday and Sunday (MOVES dayTypeID = 2).

Month VMT Fractions by TxDOT District

Month	Atlanta	Tyler
January	0.07078	0.07522
February	0.07460	0.08068
March	0.07851	0.08300
April	0.07765	0.08632
May	0.09262	0.09029
June	0.09265	0.08552
July	0.09894	0.08703
August	0.08646	0.08431
September	0.08240	0.08547
October	0.08154	0.08499
November	0.08191	0.08068
December	0.08194	0.07649

Hour VMT Fractions by TxDOT District

Hour	Atlanta		Tyler	
	Week Day[1]	Weekend Day[2]	Week Day[1]	Weekend Day[2]
1	0.013993	0.018981	0.006165	0.016284
2	0.012024	0.014792	0.004530	0.011089
3	0.011194	0.012545	0.003870	0.008790
4	0.011324	0.011278	0.004790	0.006483
5	0.013647	0.011283	0.009160	0.007118
6	0.022326	0.014299	0.022909	0.011761
7	0.034881	0.019794	0.047596	0.018931
8	0.049304	0.027291	0.078120	0.028124
9	0.048366	0.037702	0.057112	0.039544
10	0.049977	0.049259	0.050844	0.052605
11	0.053493	0.058821	0.051126	0.058846
12	0.058276	0.065533	0.052503	0.062546
13	0.061369	0.070731	0.055681	0.070928
14	0.062482	0.071772	0.057428	0.072502
15	0.064391	0.071658	0.061563	0.072453
16	0.068315	0.070880	0.069861	0.071849
17	0.070273	0.069531	0.079821	0.072518
18	0.072388	0.066691	0.089653	0.072281
19	0.058155	0.059678	0.062810	0.064649
20	0.046828	0.051520	0.043283	0.054448
21	0.039113	0.042171	0.034274	0.044683
22	0.032780	0.035006	0.026620	0.036050
23	0.025592	0.027786	0.018387	0.027131
24	0.019509	0.020998	0.011894	0.018387

[1] Monday through Friday (MOVES dayTypeID = 5).
[2] Saturday and Sunday (MOVES dayTypeID = 2).

APPENDIX K:
ANNUAL ACTIVITY AND ANNUALIZATION FACTORS

Annual VMT, Summer Weekday VMT and VMT Annualization Factors

County	Summer Weekday VMT	Annual VMT	VMT Annualization Factor
Gregg	4,112,017	1,389,391,379	337.8856
Harrison	3,017,447	930,175,255	308.2656
Rusk	1,562,919	528,087,842	337.8856
Smith	7,588,779	2,564,139,234	337.8856
Upshur	1,250,809	385,581,447	308.2656

Annual Hotelling Hours, Summer Weekday Hotelling Hours and Annualization Factors

County	Summer Weekday	Annual	Annualization Factor
Gregg	1,646.54	556,342	337.8856
Harrison	2,271.24	700,144	308.2656
Rusk	612.82	207,062	337.8856
Smith	5,418.36	1,830,784	337.8856
Upshur	405.01	124,850	308.2656

Annual Starts, Summer Weekday Starts and Annualization Factors

SUT	Gregg County			Harrison County		
	Annual	Daily	Factor	Annual	Daily	Factor
11	642,937	1,053.40	610.3435	426,949	699.52	610.3435
21	124,260,837	347,518.84	357.5658	57,883,175	161,881.20	357.5658
31	51,239,537	146,978.20	348.6200	30,112,571	86,376.49	348.6200
32	14,068,514	40,388.39	348.3307	8,268,031	23,736.16	348.3307
41	23,370	76.90	303.8848	15,426	50.76	303.8848
42	91,948	249.30	368.8170	61,002	165.40	368.8170
43	249,659	861.31	289.8613	164,945	569.05	289.8613
51	219,274	742.51	295.3135	93,703	317.30	295.3135
52	7,991,245	28,026.52	285.1315	3,597,829	12,618.14	285.1315
53	427,164	1,416.72	301.5172	70,928	235.24	301.5172
54	31,546	86.34	365.3513	13,507	36.97	365.3513
61	1,558,972	5,410.46	288.1405	253,043	878.19	288.1405
62	1,374,947	4,708.86	291.9914	531,929	1,821.73	291.9914

Annual Starts, Summer Weekday Starts and Annualization Factors - Continued

SUT	Rusk County			Smith County		
	Annual	Daily	Factor	Annual	Daily	Factor
11	253,321	415.05	610.3435	1,212,454	1,986.51	610.3435
21	38,012,399	106,308.83	357.5658	236,422,194	661,199.20	357.5658
31	20,139,223	57,768.41	348.6200	87,733,630	251,659.78	348.6200
32	5,529,499	15,874.28	348.3307	24,088,466	69,154.02	348.3307
41	7,830	25.77	303.8848	25,603	84.25	303.8848
42	30,809	83.53	368.8170	100,733	273.13	368.8170
43	83,653	288.60	289.8613	273,515	943.61	289.8613
51	73,472	248.79	295.3135	240,226	813.46	295.3135
52	2,677,629	9,390.85	285.1315	8,754,827	30,704.52	285.1315
53	143,130	474.70	301.5172	467,981	1,552.09	301.5172
54	10,570	28.93	365.3513	34,561	94.60	365.3513
61	218,330	757.72	288.1405	1,567,314	5,439.41	288.1405
62	192,558	659.46	291.9914	1,382,305	4,734.06	291.9914

Annual Starts, Summer Weekday Starts and Annualization Factors

SUT	Upshur County		
	Annual	Daily	Factor
11	307,949	504.55	610.3435
21	34,542,861	96,605.62	357.5658
31	18,805,649	53,943.12	348.6200
32	5,163,481	14,823.51	348.3307
41	9,596	31.58	303.8848
42	37,948	102.89	368.8170
43	102,610	354.00	289.8613
51	58,291	197.39	295.3135
52	2,238,159	7,849.57	285.1315
53	44,123	146.34	301.5172
54	8,402	23.00	365.3513
61	170,022	590.06	288.1405
62	357,407	1,224.03	291.9914

Annual SHP, Summer Weekday SHP and Annualization Factors

SUT	Gregg County			Harrison County		
	Annual	Daily	Factor	Annual	Daily	Factor
11	20,347,242	55,740.91	365.0325	13,516,440	37,026.32	365.0495
21	544,175,885	1,485,951.10	366.2139	253,742,521	690,165.05	367.6548
31	224,462,034	613,519.92	365.8594	132,220,848	360,504.74	366.7659
32	57,168,861	156,259.09	365.8594	33,676,531	91,820.21	366.7660
41	226,593	619.14	365.9831	148,564	404.05	367.6831
42	444,451	1,214.32	366.0072	293,004	796.84	367.7092
43	1,241,429	3,391.89	365.9991	814,846	2,216.03	367.7046
51	1,648,460	4,506.98	365.7567	691,890	1,880.32	367.9646
52	33,524,518	91,657.36	365.7591	14,826,912	40,295.06	367.9585
53	2,721,755	7,441.36	365.7603	443,278	1,204.33	368.0693
54	1,293,312	3,535.97	365.7590	543,884	1,478.07	367.9685
61	7,120,328	19,353.17	367.9154	606,077	1,489.84	406.8075
62	8,675,415	23,555.78	368.2925	1,519,555	3,568.28	425.8507

Annual SHP, Summer Weekday SHP and Annualization Factors - Continued

SUT	Rusk County			Smith County		
	Annual	Daily	Factor	Annual	Daily	Factor
11	8,018,357	21,966.50	365.0266	38,375,813	105,130.95	365.0287
21	165,957,650	453,083.19	366.2852	1,040,595,852	2,842,709.67	366.0577
31	88,015,378	240,535.04	365.9150	383,381,326	1,047,669.21	365.9374
32	22,416,901	61,262.59	365.9150	97,644,469	266,833.81	365.9374
41	75,145	205.15	366.2825	242,158	660.25	366.7701
42	147,376	402.33	366.3098	474,762	1,294.30	366.8098
43	411,638	1,123.76	366.3026	1,326,267	3,615.80	366.7972
51	541,795	1,478.96	366.3350	1,758,809	4,797.78	366.5878
52	11,019,056	30,079.13	366.3356	35,768,342	97,570.26	366.5906
53	894,386	2,441.38	366.3444	2,903,327	7,919.64	366.5984
54	425,105	1,160.43	366.3347	1,379,891	3,764.12	366.5901
61	736,265	1,947.57	378.0432	6,041,578	16,150.24	374.0859
62	857,399	2,249.18	381.2051	7,178,521	19,106.03	375.7201

Annual SHP, Summer Weekday SHP and Annualization Factors - Continued

SUT	Upshur County		
	Annual	Daily	Factor
11	9,751,377	26,713.62	365.0339
21	152,443,147	415,170.24	367.1823
31	82,947,122	226,351.64	366.4525
32	21,126,562	57,651.56	366.4526
41	93,424	254.61	366.9233
42	184,260	502.14	366.9471
43	512,410	1,396.42	366.9450
51	435,329	1,185.66	367.1619
52	9,328,622	25,407.64	367.1582
53	279,083	759.99	367.2203
54	342,191	931.97	367.1687
61	578,972	1,460.62	396.3890
62	1,627,466	4,031.52	403.6854